KIPS
ENTRY TESTS
SERIES

PHYSICS

A KIPS Publication

KIPS
10th Edition

- Quick Review of the Syllabus
- Highlighted Points
- Mind Map for Every Chapter
- Hundreds of Practice Questions
- Diagnostic Test
- Sample Paper for Entry Test
- Chapter-Wise Exercise with Answer Keys

KIPS
PREPARATIONS

CONTENT

- **This diagnostic test is designed to help you to pinpoint the weak areas in your background. Sit aside 1 hour to take this test. Check your answers with those at the end of the test. Then evaluate yourself.**

DIAGNOSTIC TEST

(1) How long would it take a car, starting from rest and accelerating uniformly in a straight line at 5 m/s^2, to cover a distance of 200 m?

(a) 9.0 s (b) 20s
(c) 10s (d) 12s

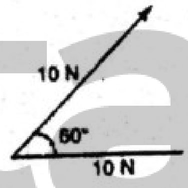
(2) Under the influence of a force, an object of mass 4 kg accelerates from 3 m/s to 6 m/s in 8 s. How much work was done on the object during this time?

(a) 54 J (b) 96 J
(c) 72 J (d) 27 J

(3) Two objects have the same mass and are located near each other at a distance (r). If the mass of one of the objects is doubled and the mass of the other object is tripled, what would be the change in gravitational attraction between them?

(a) Decrease by 1/6 (b) increases by 5
(c) Decrease by 2/3 (d) Increase by 6

(4) Two vectors A and B are acting as shown in figure. If $|\vec{A}| = |\vec{B}| = 10N$ then the resultant is



(a) $10\sqrt{2}N$ (b) $5\sqrt{3}N$
(c) 5N (d) 10 N

(5) A man lifts a body to a height of 1m in 30s. An other man lifts the same mass to same height in 60s. The work done by them is in the ratio

(a) 1:2 (b) 1:1
(c) 2:1 (d) 4:1

(6) For a particle moving in uniform circular path

(a) both velocity and acceleration are transverse
(b) both velocity and acceleration are radial
(c) velocity is transverse and acceleration is radial
(d) velocity is radial and acceleration is transverse

(7) A source of sound frequency 600Hzis placed inside the water. The speed of sound in water is 1500ms^{-1} and in air it is 300ms^{-1}.The frequency of sound recorded by an observer who is standing on air is

(a) 3000Hz (b) 900Hz
(c) 600Hz (d) 510Hz

(8) As an electron moves through magnetic field the magnitude of force on electron

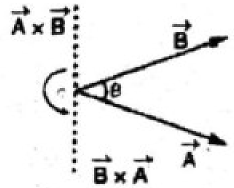
(a) decreased (b) increased
(c) remains same (d) can't predicted

(9) **How are the electrons produced in a cathode ray tube**
(a) by applying an electric field to the x plates
(b)by heating a metal filament
(c) by ionization of the air
(d) by radioactive decay

(10) **The time of a flight of projectile is 4sec. After 1 sec it moves an angle of 45^0. its angle of projection is**
(a) $\tan^{-}(2)$ (b) $\tan^{-1}(4)$
(c) $\tan^{-1}(1)$ (d) $\tan^{-}(2/3)$

(11) **A stone A is dropped from the top of tower of height of 40m. At the same time another stone B is projected from the bottom of the tower with an initial velocity such that the stones collide midway. The initial speed of second stone B is**
(a) $5ms^{-1}$ (b) $20ms^{-1}$
(c) $15ms^{-1}$ (d) $10ms^{-1}$

(12) **Angle between A x B and B x A is :**



(a) π (b) 2π
(c) $\pi/6$ (d) none of these

(13) **The value of e/m for positive rays is**
(a) > e/m of cathode rays (b) < e/m for cathode rays
(c) equal to e/m of cathode rays (d) none of above

(14) **The equation represent actinium decaying to thorium**
${}_{89}Ac^{227} \rightarrow {}_{90}Th^{227} + Y$, Which particles does Y represent
(a) alpha (b) beta
(c) gamma (d) neutron

(15) **All of the following are unit of energy except**
(a) erg (b) kilo watt
(c) joule (d) kilowatt hour

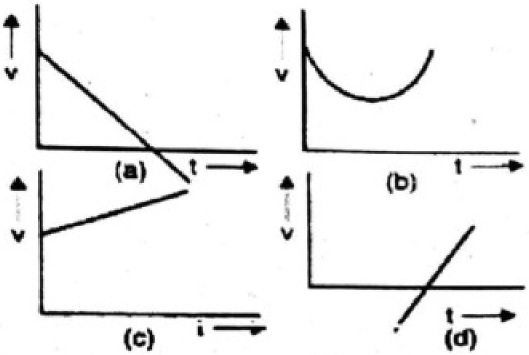
(16) **One of the rectangular components of a force is 10N making an angle of 60 with force. The magnitude of force is**
(a) 17.1 N (b) 14.1N
(c) 17.3N (d) 20N

(17) **The height at which the acceleration due to gravity becomes g/9 (where *g* = the acceleration due to gravity on the surface of the earth) in terms of *R*, the radius of the earth, is**
(a) $R/2$ (b) $\frac{R}{\sqrt{2}}$
(c) $\sqrt{2}R$ (d) (d) 2R

(18) **When an A.C source is connected across a resister**
(a) current leads the voltage in phase
(b) current lags behind voltage in phase
(c)current and voltage are in same phase
(d) any one of above may be true depending upon resistance

(19) **Which of the following does not effect the motion of moving electron**
(a) electric field applied in direction of motion
(b) Mag. Field applied indirection of motion
(c) electric field perpendicular to direction of motion
(d) mag field perpendicular to direction of motion

(20) **A stone is released from a balloon moving upward with velocity 'v' at height h . Which of the following graphs is best representation of velocity-time graph for the motion of stone**



(21) **An electron is injected into a uniform magnetic field with components of velocity parallel to and normal to the field direction. The path of the electron is a**
(a) helix (b) circle
(c) parabola (d) straight line

(22) **Doppler shift in frequency does not depend upon**
(a) actual frequency of the wave (b) distance of source from listener
(c) velocity of sound (d) velocity of observer

(23) **Velocity of sound is greater in solids than in gases because**
(a) density of solids is high and elasticity is low
(b) both density and elasticity are low
(c) density is low and elasticity is high
(d) elasticity of solids is very high

(24) **The dimensions of which of the following are same as that of impulse**
(a) momentum (b) velocity
(c) force/time (d) none

(25) **The distances traveled by body falling from rest in the 1st, 2nd & 3rd seconds are in the ratio**
(a) 1:2:3 (b) 1:3:5
(c) 1:2:9 (d) none

(26) **A ball covers a distance of 5m when projected with a speed of 10m/s. What are the two possible angles of projection ($g = 10m/s^2$)**
(a) 45°, 45° (b) 30°, 60°
(c) 15°, 75° (d) 10°, 30°

(27) **Two bodies having K.E in ratio 4:1 and masses in ratio 1:4 have linear momentum in ratio**
(a) 1:1 (b) 1:2
(c) 2:1 (d) 1:4

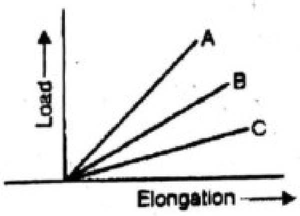
(28) **How much the momentum of a body would increase by increasing the K.E by 300%**
(a) 50% (b) 75%
(c) 100% (d) 150%

(29) **An artificial satellite of the earth releases a packet. If air resistance is neglected, the point where the packet will hit, will be:**
(a) behind
(b) ahead
(c) exactly below
(d) it will never reach the earth

(30) **If the following properties of a wave the one that is independent of others is**
(a) amplitude
(b) velocity
(c) frequency
(d) wavelength

(31) **The temp at which a ferromagnetic material becomes a paramagnetic material is called**
(a) critical temperature
(b) inversion temp
(c) curie temp
(d) neutral temp

(32) **Elongation-load graph within elastic limit is shown in figure of three wires A, B and C made of same material and of same length. The thickest wire is :**



(a) same for all
(b) C
(c) B
(d) A

(33) **If current in a electric bulb drops by 1%, the power decreases by**
(a) 1%
(b) 2%
(c) 4%
(d) 0.5%

(34) **Total energy of a particle performing S.H.M is directly proportional to**
(a) Amplitude
(b) Square root of amplitude
(c) square of amplitude
(d) Reciprocal of amplitude

(35) **Beats are the result of :**
(a) destructive interference
(b) constructive and destructive interference
(c) superposition of two waves of nearly equal frequencies
(d) diffraction

(36) **$_{92}U^{238}$ decays through a series of transformation to a final stable nuclide. The particles emitted in the successive transformations are**

$\alpha\, \beta\, \beta\, \alpha\, \alpha$

Which nuclide is not produced during the series
(a) $_{91}Pa^{234}$
(b) $_{88}Ra^{226}$
(c) $_{92}U^{235}$
(d) $_{92}U^{234}$

(37) **A young's double slit set up for interference is shifted from water to air than fringe width**
(a) fringe width increased
(b) fringe width decreases
(c) fringe width remain same
(d) fringe pattern disappears

(38) **Two different light bulbs are in a DC circuit powered by an 18 V battery as its power source. The two bulbs are rated at 4.5 watts (B_1) and 6.75 watts (B_2) each. What are the resistances of the two light bulbs (B_1) and (B_2)?**
(a) B_1 is 2.67 Ω, and B_2 is 4 Ω
(b) B_1 is 48 Ω, and B_2 is 72 Ω.
(c) B_1 is 72 Ω, and B_2 is 48 Ω
(d) B_1 is 4 Ω, and B_2 is 2.67 Ω

(39) **In a purely capacitive circuit the current.**
(a) leads the emf by π/2
(b) lags the emf by π/2
(c) are in phase
(d) both (a & c)

(40) From the top of a tower of height h a particle was thrown horizontally with velocity $(2gh)^{1/2}$. It strikes the ground at a distance from the foot of the tower equal to

(a) h (b) h/2
(c) 2h (d) 3h/2

(41) A particle is moving is a circular path with a constant speed v. The magnitude of change in velocity after it has designed an angle of $60°$ is

(a) $\sqrt{3}v$ (b) $\sqrt{2}v$
(c) v (d) $\frac{\sqrt{3}}{2}v$

(42) The angle of projection for which the max height and horizontal range are equal is

(a) 35^0 (b) $\tan^{-1}(1/4)$
(c) 60^0 (d) $\tan^{-1}(4)$

(43) All of the following are examples of electromagnetic waves EXCEPT

(a) sound waves. (b) gamma rays.
(c) radio waves (d) X-rays.

(44) A radioisotope has a half-life of 5 years. The fraction of atoms of this material that would decay in 15 years will be

(a) 1/8 (b) 3/8
(c) 5/8 (d) 7/8

(45) What is the charge on an α-particle?

(a) 1.51×19^{-19}C (b) 3.18×10^{-19}C
(c) 4.78×10^{-19}C (d) zero

(46) Which of the following waves have longest wavelength

(a) x-rays (b) infrared
(c) radio waves (d) visible light

(47) Two balls A and B are thrown from a running train ball A is just dropped while B is thrown horizontal outwards. Which of the two will reach the ground earlier.

(a) ball A (b) ball B
(c) both at same time (d) data is inadequate

(48) A particle executing one-dimensional motion finally comes to rest what will be the angle between acceleration and displacement during motion.

(a) 0 (b) π
(c) π/2 (d) π/4

(49) E,M,L and G denote energy, mass, angular momentum and gravitation constant respectively. The dimensions of EL^2/M^5G^2

(a) time (b) length
(c)mass (d) angle

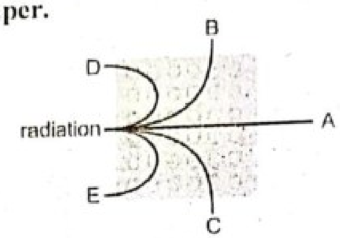
(50) In interference pattern, energy is

(a) created at the position of maximum (b) destroyed at the position of minimum
(c) conserved but is redistributed (d) not conserved

(51) Two resistors In parallel have their resistances in the ration 1:3. A source is connected to the combination. The ratio of heats produced in a given time in the two resistors is

(a) 3:1 (b) 9:1

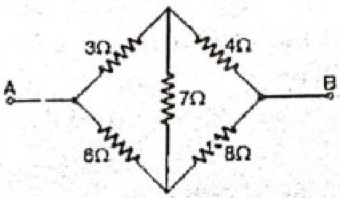
(52) Which line shows the path of alpha radiation in a magnetic field? Magnetic field is directed out of the plane of paper.



(a) B
(b) D
(c) C
(d) E

(53) A pile of 11 books weighing 2 N each is lying on a table. With what total force does the table push back on the books?
(a) 11N
(b) 22N
(c) 44N
(d) 110N

(54) Five resistances have been connected as shown in figure, the effective resistance between A and B is:



(a) 26 ohm
(b) 46 ohm
(c) 4.6 ohm
(d) 2.8 ohm

(55) The uranium atom $_{92}U^{238}$ emits an α particle to become thorium which emits β particle to become protactinium. What is the atomic number of protactinium
(a) 90
(b) 91
(c) 89
(d) 92

(56) A convex lens of power 4 diopter is combined with a concave lense of power 3 adopter. The combination will behave as a
(a) Concave lense of .5m focal length
(b) Convex lense of .5m focal length
(c) Concave lense of 1m focal length
(d) Convex lense of 1m focal length

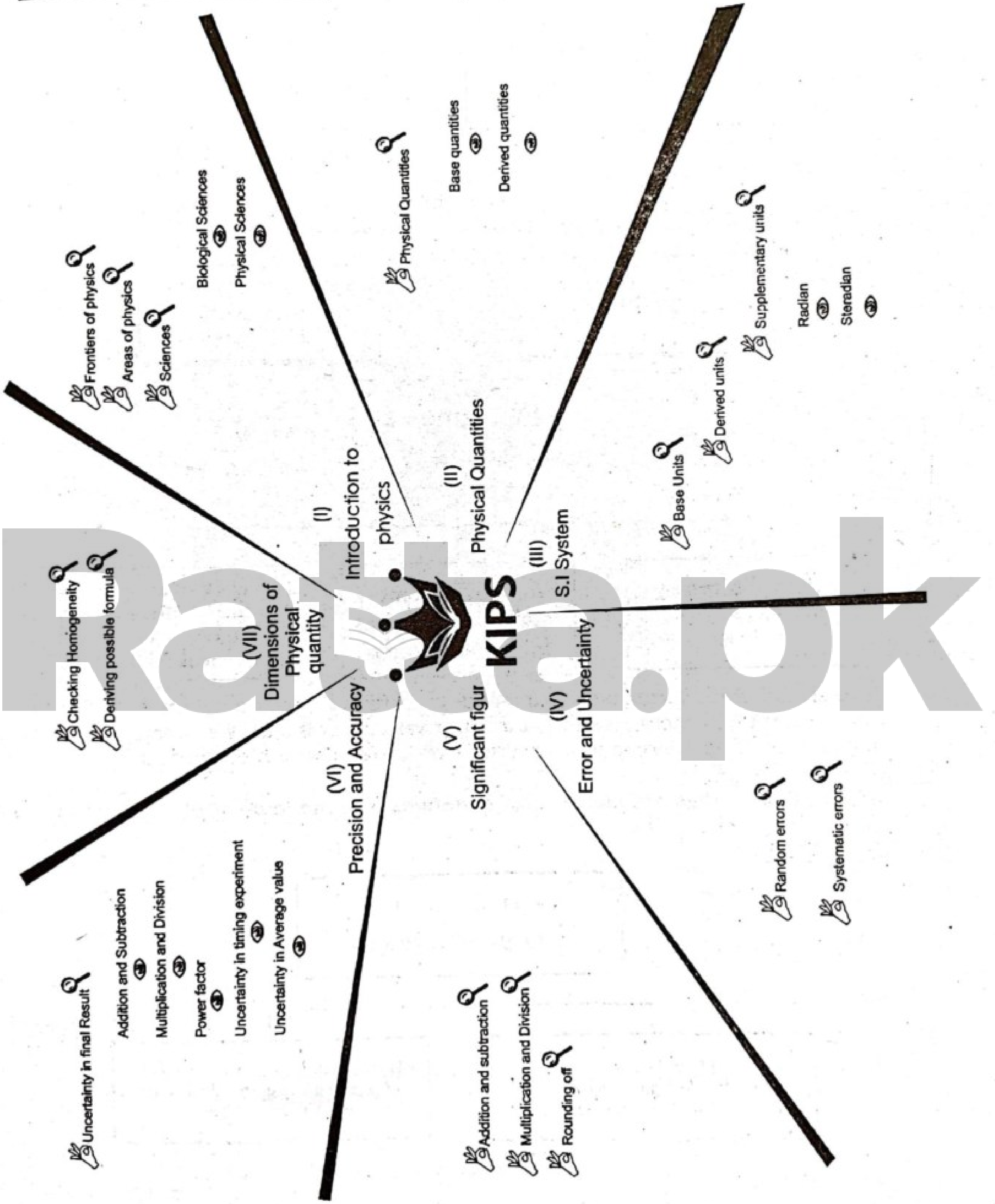
(57) A radioactive isotope has a half life of 2minutes. What can be deduced from this statement.
(a) after 1/2 minute, 1/4 of the isotope remain
(b)after 1 minute, 1/4 of the isotope remains
(c) after 4 minutes, 1/4 of the isotope remains
(d) after 4 minutes, none of isotope remains

(58) A boat is sent across a river with a velocity of 8km/h. If the resultant velocity of boat is 10 km/h, the river is flowing with a velocity of
(a) 12km/h
(b) 6km/h
(c) 10km/h
(d) 2km/h

(59) The displacement of a body is zero. The distance covered by it
(a) is zero
(b) is not zero
(c) may or may not be zero
(d) depends upon acceleration

(60) A neutron of mass m moves with velocity 'v' at an angle of 60 to the direction of magnetic field 'B'. The force experienced by the neutron is
(a) B
(b) BV cos 60
(c) BV sin 60
(d) Zero

Chapter 1 MEASUREMENTS



INTRODUCTION

Physics

"Physics is an experimental science that deals with the study of matter, energy and their mutual relationship".

Biological sciences (dealing with living things)

Physical Sciences (concerned with non living things)

Fundamental Sciences

World of extremely large things. Such as universe.

World of extremely small things. Such as Electrons, protons

World of complex matter or middle sized things, such as molecules

The silicon chips (processed form sand) are utilized in the development of computers and electronic devices use to control the various systems. We create networks from computers, thus interconnecting various work stations with each other.

PHYSICAL QUANTITIES

Physical quantities are measurable quantities and the laws of physics are expressed in terms of them.

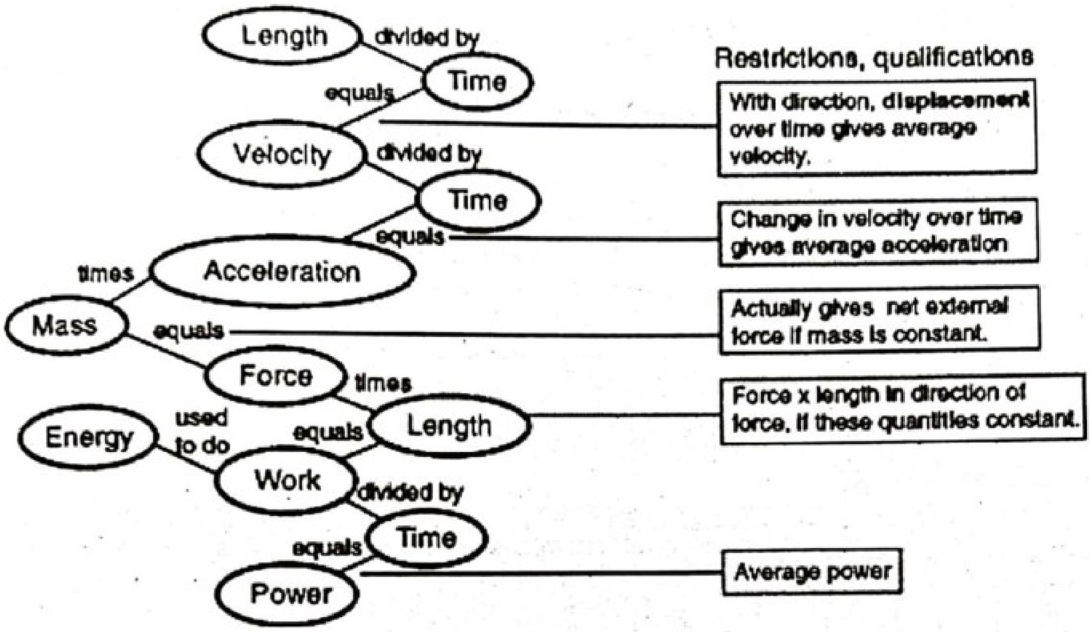
CLASSIFICATION

Physical Quantities

Base quantities could not be expressed in term of other quantities

Derived quantities could be expressed in terms of other quantities

CHAIN OF MECHANICAL QUANTITIES



Measurements of the quantities require the following steps.

- Comparison of quantity to be measured with a standard measuring tool.
- Encoding the result of comparison in standard format containing a suitable precise number along with appropriate unit.

✦ *Basic quantities* ⇒ could not be expressed in term of other quantities

✦ *Derived quantities* ⇒ based on the other physical quantities

- Measurement of basic quantities requires *the choice of standard.*
  Ideal standard should be accessible & invariable.
  Prior 1960, three measuring systems were in practice.
- CGS System (centimeter, gram, second)
- FPS System (foot, pound, second), or British Engineering system.
- MKS System (meter, kilogram, second)
  After 1960, internationally accepted standard is SI system. In system international (SI), there are three types of units.

Do you know?

Ideal standard measuring tool should be fool proof via accessibility & invariability.

Supplementary Units

Physical Quantity	SI Unit	Symbol
Plane angle	Radian	rad
Solid angle	Steradian	sr

Basic Mechanical Units

	SI Units (MKS)	(CGS)	U.S. Common
Length (L)	meter (m)	centimeter (cm)	foot (ft)
Time (T)	second (s)	second (s)	second (s)
Mass (M)	kilogram (kg)	gram (gm)	slug
Velocity (L/T)	m/s	cm/s	ft/s
Acceleration (L/T^2)	m/s^2	cm/s^2	ft/s^2
Force (ML/T^2)	kg m/s^2=Newton(N)	gm cm/s^2= dyne	slug ft/s^2=pound(lb)
Work (ML^2/T^2)	N m = joule (j)	dyne cm = erg	lb ft = ft lb
Energy (ML^2/T^2)	joule	erg	ft lb
Power (ML^2/T^3)	j/s = watt (W)	erg/s	ft lb/s

Note: *Many other derived units are also used for other derived quantities.*

SCIENTIFIC NOTATION

The standard to express the number in term of power of ten is called scientific notation. Some standard prefixes for power of ten with their symbols are presented below:

Factor	*Prefix*	*Symbol*
10^{-18}	*atto*	*a*
10^{-15}	*femto*	*f*
10^{-12}	*pico*	*p*
10^{-9}	*nano*	*n*
10^{-6}	*micro*	*u*
10^{-3}	*milli*	*m*
10^{-2}	*centi*	*c*
10^{-1}	*deci*	*d*
10^{1}	*deca*	*da*
10^{3}	*kilo*	*k*
10^{6}	*mega*	*M*
10^{9}	*giga*	*G*
10^{12}	*tera*	*T*
10^{15}	*peta*	*P*
10^{18}	*exa*	*E*

Do you know?
There should be one non-zero digit to the left of decimal in scientific notation.

ERROR

The difference between standard and experimental values is error.

Classification of Errors

- Assignable Errors (systematic errors)
- Un assignable Errors (Random errors)

Assignable Errors

The errors to which we can assign a cause usually they follow same trend of variations so a cause can be assigned to them e.g. Errors occurring due to the L.C of the measuring instrument.

Remedy

Such errors can be controlled experimentally while carefully monitoring the measurement process.

Un Assignable Errors

To which we can't assign a cause because they do not follow a trend. So these errors are due to unknown causes.

Remedy

These errors can't be controlled experimentally, but a statistical tool of taking average of several values is employed to minimize them.

SIGNIFICANT FIGURES

Uncertainty in the measurements leads us to establish some standard to write the numerical value of a measurement, termed as significant figure.

"In any measurement, all the accurately known digits and the first doubtful digit are named as significant figures."

Do you know?

Greater the significant figures in a measurement the more accurate it is

Rules of significant figures

In order to determine significant figures in a number we must follow the following rules:

(1) All the non-zero digits are significant figures.

For Example:

3.456 has four significant figures.

12.3456 has six significant figures.

(2) Zeros between non-zero digits are significant.

For Example:

2306 has four significant figures.

20,0894 has six significant figures.

(3) Zeros locating the position of decimal in numbers of magnitude less than one are not significant.

For Example:

In the 0.2224 and 0.000034, zeros are not significant.

(4) Final zeros to the right of the decimal point are significant.

For Example:

3.0000 has four significant zeros.

1002.00 has four significant zeros.

(5) Zeros that locate decimal point in numbers greater than one are not significant.

For Example:

30000 has only one significant figure.

120000 has two significant figures.

Algebra with Significant Figures

(i) Division and Multiplication

(a) $$\frac{4.54 \times 2.324}{1.3365} = 7.89447063 = \left(\begin{array}{l}\text{an answer having maximum}\\ \text{of three digits can be retained here}\end{array}\right) = 7.89$$

(b) $$4.3458 \times 2.7 = 11.73366 = \left(\begin{array}{l}\text{an answer having maximum}\\ \text{of two digits can be retained here}\end{array}\right) = 12$$

- The factor having the smallest number of significant figures is called least accurate factor, and product and quotient cannot have number of significant figures more than that in the least accurate factor.

(ii) Addition and Subtraction

Search for the least number of decimal places, counting the number of significant figures is not required. For example:

(a) $$4.345 + 23.51 = 27.855 = \left(\begin{array}{l}\text{an answer having maximum}\\ \text{of two decimal places}\end{array}\right) = 27.86$$

(b) $101.2401 - 1.0 = 100.2401 = \begin{pmatrix}\text{an answer having maximum} \\ \text{of one decimal place}\end{pmatrix} = 100.2$

(c) $101.2401 - 1 = 100.2401 = \begin{pmatrix}\text{an answer having no} \\ \text{decimal place}\end{pmatrix} = 100$

ROUNDING OFF DATA

Rule # 1:

If the digit to be dropped is greater than 5, then add "1" to the last digit to be retained and drop all digits farther to the right.

For example:

3.677 is rounded off to 3.68 if we need three significant figures in measurement.

3.677 is rounded off to 3.7 if we need two significant figures in measurement.

Rule # 2:

If the digit to be dropped is less than 5, then simply drop it without adding any number to the last digit.

For example:

6.632 is rounded off to 6.63 if we need three significant figures in measurement.

6.632 is rounded off to 6.6 if we need two significant figures in measurement.

Rule # 3:

If the digit to be dropped is exactly 5 then:

(A) If the digit to be retained is even, then just drop the "5"

For example:

6.65 is rounded off to 6.6 if we need two significant figures in measurement.

3.4665 is rounded off to 6.466 if we need four significant figures in measurement.

(B) If the digit to be retained is odd, then add "1" to it.

For example:

6.35 is rounded off to 6.4 if we need two significant figures in measurement.

3.4675 is rounded off to 6.468 if we need four significant figures in measurement.

Remember: Zero is an even number

3.05 is rounded off to 3.0 if we need two significant figures in measurement.

PRECISION & ACCURACY

Precision

The precision of a measurement is determined by the least count of the instrument or device.

Smaller the least count of instrument, more precise is the measurement.

Accuracy

The accuracy of a measurement depends upon the fractional or percentage uncertainty in the measurement.

Smaller the percentage error, more accurate is the measurement. Maximum absolute uncertainty is equal to one least count of the measuring instrument.

Assessment of Total Uncertainty in the Final Result

Total uncertainty in the final result can be determined by the following rules:

- In case of addition and subtraction absolute uncertainties are to be added.
- In case of multiplication and division fractional or percentage errors are to be added.
- For power factor the power is multiplied with the percentage uncertainty.

For example: In the equation $u = kx^a$, a × percentage error in x, where k is constant of proportionality.

Uncertainty in the average value of many measurements of the same quantity is the mean of absolute differences of measurements form the average value.

- For time measurement, uncertainty is obtained by dividing the least count of the timing device with the number of vibrations.

Do you know?
Counting more number of vibrations can reduce the uncertainty in the timing experiments.

DIMENSIONS

Each basic measurable physical quantity is represented in term of base quantities by a specific symbol for them written with in square brackets is called dimension.

- The dimensions are helpful in-
- ✦ Deriving a possible formula
- ✦ Checking the homogeneity of a physical equation or formula.

Limitations of Dimensional Analysis

- Dimension analysis has no information on dimensionless constants.
- If a quantity is dependent on trigonometric or exponential function, this method cannot be used.
- In some cases, it is difficult to guess the factors while deriving the relation connecting two or more physical quantities.
- This method cannot be used in an equation containing two or more variables with same dimensions.

PRACTICE EXERCISE

30 mins
Time Yourself

(1) **A nanosecond is:**
(a) 10^{9} s
(b) 10^{-10} s
(c) 10^{-1}s
(d) 10^{-9} s

(2) **The dimension of energy density is same as that of**
(a) pressure
(b) force
(c) (velocity $)^2$
(d) acceleration

(3) **$(5.0\times10^4)\times(3.0\times10^6)=$**
(a) 1.5×10^9
(b) 1.5×10^{11}
(c) 1.5×10^{10}
(d) 1.5×10^{21}

(4) **For what physical quantity is the pascal a unit?**
(a) stress
(b) pressure
(c) Young's modulus
(d) all of these

(5) **In scientific notation numbers are expressed in**
(a) power of ten
(b) powers of two
(c) reciprocal
(d) decimal

(6) **1024 can be written in scientific notation as**
(a) $1.024\text{x}10^3$
(b) 2^{10}
(c) 0.000976
(d) 1/0.00097

(7) **Prefix deca represents**
(a) 10^1
(b) 10^2
(c) 10^3
(d) 10^{-1}

(8) **The error in measurement may occur due to**
(a) inexperience of a person
(b) the faulty apparatus
(c) inappropriate method
(d) due to all reasons in a , b and c

(9) **The uncertainty in a measurement may occur due to**
(a) limitation of an instrument
(b) natural variation of the object to be measured
(c) inadequate technique
(d) all given in a, b and c

(10) **Random errors can be reduced by**
(a) taking zero correction
(b) comparing the instrument with another more accurate one
(c) taking mean of several measurement
(d) all methods explained in a, b and c

(11) **In any measurement the significant figures are**
(a) all accurately known and all doubtful digits
(b) only accurately known digits
(c) only doubtful digits
(d) all accurately known digits and the first doubtful digit

(12) **A digit zero in a measurement**
(a) may be significant or may not be significant
(b) always significant
(c) always insignificant
(d) significant only if left to a significant figure

(13) **Number of significant figures in 0.0173 are**
(a) three (b) four
(c) five (d) two

(14) **Smaller the least count of the instrument more is the measurement**
(a) accurate (b) precise
(c) accurate and precise (d) none of these

(15) **The number of significant figures in 15.0 is/are**
(a) 2 (b) 6
(c)1 (d) 3

(16) **What comparing systematic and random errors, the following pairs of properties of errors in an experimental measurement may be contrasted:**
P_1: error can possibly be eliminated
P_2: error cannot possibly be eliminated
Q_1: error is of constant sign and magnitude
Q_2: error is of varying sign and magnitude
R_1: error will be reduced by averaging repeated measurements
R_2: error will not be reduced by averaging repeated measurements
Which properties apply to random error?
(a) P_1, Q_1, R_2 (b) P_2, Q_2, R_1
(c) P_1, Q_2, R_2 (d) P_2, Q_1, R_1

(17) **Dimensional analysis is helpful for**
(a) deriving a possible formula
(b) checking the homogeneity of a physical equation
(c) verification of laws
(d) only a and b are correct

(18) **Which equation is not dimensionally correct?**
(a) $E=mc^2$ (b) $V_f=V_i+at$
(c) $S=Vt^2$ (d) $S=\frac{1}{2}at^2$

(19) **SI unit of coefficient of viscosity is**
(a) $kg.m.s^{-1}$ (b) $kg\ m^{-1}.s^{-1}$
(c) kg.m.s (d) $kg^{-1}.m^{-1}.s^{-1}$

(20) **Three students measured length of a needle with meter rod and recorded as: (i) 0.2145m (ii) 0.21m (iii) 0.214m. Which one is correct record?**
(a) only (i) (b) only (ii)
(c) only (iii) (d) both (i) and (ii)

(21) **One light year is equal to**
(a) 9.5×10^{15}m (b) 9.5×10^{15}sec
(c) 9.5×10^{15}Km (d) 9.5×10^{15}cm

(22) **The energy of a photon of light of frequency f is given by hf, where h is the Planck constant. What are the base units of h?**
(a) $kg\ m\ s^{-1}$ (b) $kg\ m^2\ s^{-1}$
(c) $kg\ m^2\ s^{-2}$ (d) $kg\ m^2\ s^{-3}$

Js $E=\frac{h}{s}$
Nms Js
kg m s^{-2} s Nms
kgms^{-2}s
kgm...

(23) **Steradian is the SI unit of**
(a) plane angle (b) solid angle
(c) both plane angle and solid angle (d) neither plane angle nor solid angle

(24) Which pair has same dimension

(a) work, torque
(b) work, energy
(c) energy, torque
(d) all are correct

(25) Total uncertainty, in result obtained from the subtraction of two measurement, is equal to

(a) sum of their absolute uncertainties
(b) difference of their absolute uncertainties
(c) product of their absolute uncertainties
(d) division of their absolute uncertainties

(26) Which one is the highest power multiple?

(a) giga
(b) peta
(c) mega
(d) deca

(27) One femto stands for

(a) 10^{-15}
(b) 10^{-12}
(c) 10^{-9}
(d) 10^{-6}

(28) Percentage uncertainty in radius r is 2%. The percentage uncertainty in volume of sphere is $4\pi r^2$

(a) 4%
(b) 6%
(c) 8%
(d) 9%

(29) The unit of force is __________ and its symbol is __________. Which is the correct pair?

(a) Newton, n
(b) Newton, N
(c) newton, n
(d) newton, N

(30) Which quantity has different units from the other three?

(A) Weight
(c) The Young modulus × area
(c) Rate of change of momentum
(d) Density × volume × velocity

(31) Which one is the derived quantity in SI units?

(a) electric current
(b) electric charge
(c) mass
(d) amount of substance

(32) Which one is the correct representation of the unit of pressure?

(a) Newton/Meter^2
(b) newton/meter^2
(c) Newton/meter^2
(d) newton/Meter^2

(33) In an experiment to determine the acceleration of free fall g, the period of oscillation T and length ℓ of a simple pendulum were measured. The uncertainty in the measurement of ℓ was estimated to be 4% and that of T, 1%. The value of g was determined using the formula $g = \dfrac{4\pi^2 \ell}{T^2}$.

What is the uncertainty in the calculated value for g?

(a) 2%
(b) 6%
(c) 5%
(d) 8%

(34) Which experimental technique reduces the systematic error of the quantity being investigated?

(a) Adjusting an ammeter to remove its zero error before measuring a current

(b) Measuring several inter-nodal distance on a standing wave to find the mean inter-nodal distance

(c) Measuring the diameter of a wire repeatedly and calculating the average

(d) Timing a large number of oscillations to find a period

(35) **In multiplication and division of measurement**

(a) percentage uncertainties are added (b) absolute uncertainties are added

(c) percentage uncertainties are divided (d) absolute uncertainties are divided

(36) **The number of significant figures in 5.400 are**

(a) thee (b) five

4 (c) two (d) four

(37) **Which of the following could be measured in the same units as force?**

(a) Momentum × distance (b) Energy × distance Nmm

(c) Energy/time (d) Energy/distance

(38) **The number of significant figures in the length of a bar 9800mm measured by meter rod are**

(a) four (b) three

(c) two (d) none of these

(39) **A radio aerial of length L, when the current is I, emits a signal of wavelength λ and power P. These quantities are related by**

$$P = kI^2\left(\frac{L}{\lambda}\right)^2$$

Where k is a constant. What unit, if any, should be used for the constant k?

(a) Volt (b) watt

(c) ohm (d) No unit

(40) **Which of the following is not a correct representation method for prefixes**

(a) 1mm (b) 10km

(c) 1000μm (d) both "a" and "b"

Chapter 2

VECTORS AND EQUILIBRIUM

KIPS

- (I) Concepts of vectors
  - Rectangular coordinate system
  - Addition and subtraction of vectors
  - Resultant vectors
  - Multiplication of vectors
  - Types of vectors
    - Unit vector
    - Position vector
    - Null vector
    - Negative vector
- (II) Vector Addition by Rectangular components
  - X – Component of vector
  - Y – Component of vector
  - Direction of resultant vector
  - Magnitude of Resultant vector
- (III) Product of vector
  - Scalar product
  - Vector product
- (V) Equilibrium
  - 1st condition of equilibrium
  - 2nd condition of Torque
  - Rotational equilibrium
  - Translational equilibrium
  - Equilibrium of forces
  - Equilibrium of Torque
- (VI) Torque
  - Line of action of force
  - Moment Arm
  - Couple

INTRODUCTION

Physical Quantities
(A property of the matter associated with measurement)

Scalar quantity
(having magnitude but no direction)

Vector quantity
(having magnitude as well as direction)

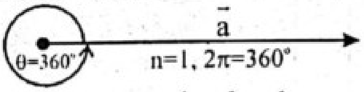
COMPARISON OF SCALAR AND VECTOR

Particulars	Scalars	Vectors
Definition.	*Non-directional physical quantity*	*Directional physical quantity*
Examples	*time, volume, work & flux*	*Displacement, velocity & torque*
Representation requirements	*Numerical value* *Proper unit*	*Numerical value* *Proper unit* *Direction*
Subtraction	*By simple arithmetic rules*	*By special rules*
Addition	*By simple arithmetic rules*	*By special rules*
Multiplication	*By simple arithmetic rules*	*By special rules*
Division	*By simple arithmetic rules*	*Not possible*

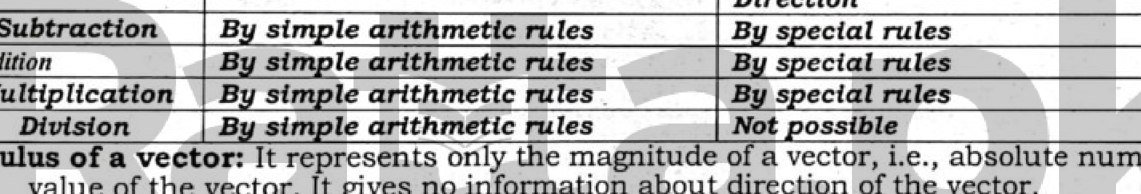
Modulus of a vector: It represents only the magnitude of a vector, i.e., absolute numerical value of the vector. It gives no information about direction of the vector.

If $\vec{a} = (5N)(East)$, $\vec{b} = (-5N)(West)$ then $\vec{a} \neq \vec{b}$ but $|\vec{a}| = |\vec{b}| = 5N$

- **A vector does not change: (i)** When a vector is displaced parallel to itself anywhere in space. **(ii)** When a vector is rotated through an angle θ keeping its tail fixed such that $\theta = 2n\pi$ where n = 1, 2, 3, ...



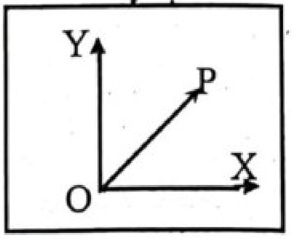
- **A vector changes when: (i)** Its magnitude changes only. **(ii)** Its direction changes only, i.e., angle of rotation of a vector is not an integral multiple of 2π. **(iii)** Both magnitude and direction change.
- **Angle between two vectors:** It is measured only when their tails or heads are at the same point.



VECTOR REPRESENTATION

VECTORS

- ***Symbolic representation***
  - *Arrowhead representation* ($\overrightarrow{\text{representation}}$)
  - Bold face representation
- *Graphical representation*



STEPS TO REPRESENT VECTORS GRAPHICALLY

Do You Know?
Angular representation of vectors involves measurement of angle with positive x-axis in anticlockwise sense.

Representation

- Select suitable scale
- Draw a line of selected magnitude according to scale
- Put an arrowhead in the direction of vector to be represented.

Rectangular Coordinate System

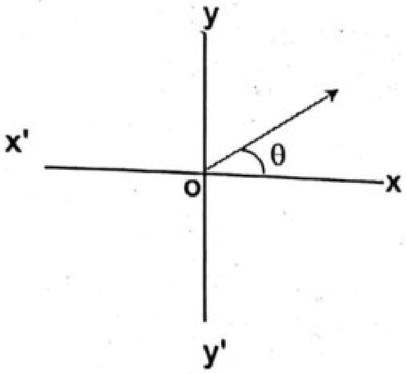
Two-dimensional

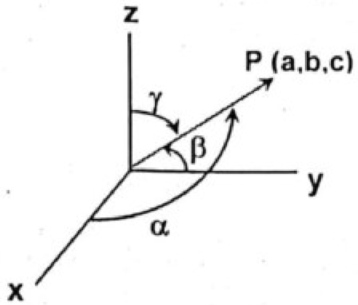
It consists of two mutually perpendicular intersecting lines, called x-axis and y-axis. One angle is enough to specify the direction of a vector in two-dimensional coordinate system.

Three-dimensional

It consists of three mutually perpendicular lines called x-axis, y-axis and z-axis.

The direction of a vector in three dimensional rectangular coordinate system is specified by three angles making with x, y and z-axis respectively.





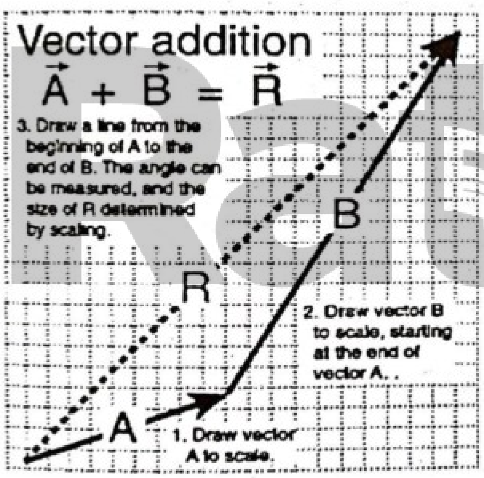
Origin

It is the point of intersection of mutually perpendicular lines in rectangular coordinate system.

ADDITION AND SUBTRACTION OF VECTORS

- We can add and subtract vectors by head to tail rule that states:
  "If vectors are arranged in such a way that tail of each next vector join with the head of its preceding vector, then the resultant is obtained by joining tail of first vector with the head of last one."

GRAPHICAL VECTOR ADDITION



Adding two vectors **A** and **B** graphically can be visualized like two successive walks, with the vector sum being the vector distance from the beginning to the end point. Representing the vectors by arrows drawn to scale, the beginning of vector B is placed at the end of vector A. The vector sum R can be drawn as the vector from the beginning to the end point.

The process can be done mathematically by finding the components of A and B, combining to form the components of R, and then converting to polar form. (R,θ)

TYPES OF VECTORS

Resultant Vector

It is a single vector that has the same effect as all the vectors to be added.

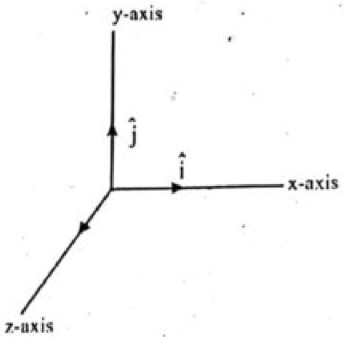
Unit Vector

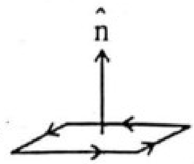
It has magnitude **1** and direction of it is along the given vector. It is obtained by dividing the vector with its magnitude i.e. $\hat{A}=\frac{\overline{A}}{|\overline{A}|}$.

"A unit vector has no dimensions and it is unitless."

Some commonly used unit vectors are

- $\hat{i}$ - *unit vector along x-axis*
- $\hat{j}$ - *unit vector along y-axis*
- $\hat{k}$ - *unit vector along z-axis*
- $\hat{r}$ - *unit vector along position vector*
- $\hat{n}$ - *unit vector along normal (perpendicular)*



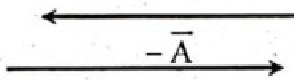


Zero Vector or Null Vector

It has magnitude zero and arbitrary direction. Its symbol is **O** and used as vector identity for addition.

Negative of a vector

It is a vector of same magnitude but has opposite direction e.g. $\vec{A}$



POINT TO PONDER

We cannot add zero to null vector.

Equal Vectors

Vectors having same magnitude and same direction are said to be equal vectors.

Parallel Vectors

The vectors that have only same direction are called parallel vectors

Anti parallel Vectors

The vectors that have opposite direction are called anti parallel vectors.

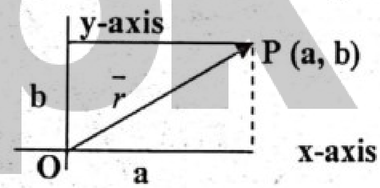
Position Vector

It represents the position of a point with respect to a origin in a coordinate system.

Its symbol is $\vec{r}$.

In two dimensions, $\vec{r} = a\hat{i} + b\hat{j}$

In three dimensions, $\vec{r} = a\hat{i} + b\hat{j} + c\hat{k}$



MULTIPLICATION OF A VECTOR WITH A SCALAR (NUMBER)

- Resultant remains a vector
- Magnitude may or may not be changed as number can be 1 or >1.
- Direction may or may not be changed, as number can be positive or negative.
- e.g. if number = n & vector = $\vec{A}$, then after multiplication

  New vector $= n\vec{A}$

  Magnitude = n times the magnitude of $\vec{A}$ i.e. $n\vec{A}$

Dimensions of scalar and vector are also multiplied to give the dimension of new vector.

RESOLUTION OF A VECTOR

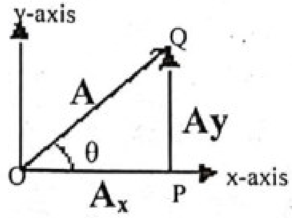
- Reverse process of addition of vectors.
- Replacing single vector by two or more than two vectors.
- Vectors obtained by resolving a vector are called components.
- Component of a vector is its effective value in the stated direction.
- Minimum possible components of a vector are two.
- Maximum possible components of a vector are infinite.

RECTANGULAR COMPONENTS OF A VECTOR

- Components of vector which are mutually perpendicular.
- To apply simple trigonometric formulae we resolve vector in a plane into two mutually perpendicular components called rectangular components e.g. Where

  $A_x = A\cos\theta$------------ (i)

  $A_y = A\sin\theta$-------------(ii)



- Direction of components is governed by angle 'θ'.

DETERMINATION OF A VECTOR FROM RECTANGUALR COMPONENTS:

Squaring and adding (i) and (ii), their simplification yields.

$$|\overline{A}| = \sqrt{A_x^{\,2} + A_y^{\,2}} \qquad (\cos^2\theta + \sin^2\theta = 1)$$

For direction dividing (i) and (ii)

$$\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

ADDITION OF VECTORS BY RECTANGULAR COMPONENTS

- Let resultant of two vectors **A** and **B** be R. Its magnitude is given as

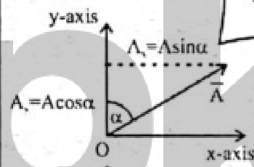
$$R = \sqrt{(R_x)^2 + (R_y)^2}$$

Where

$R_x = A_x + B_x$

$R_y = A_y + B_y$

DO YOU KNOW THIS



$\overline{A} = A_x\hat{i} + A_y\hat{j}$

$\frac{\overline{A}}{A} = \frac{A_x}{A}\hat{i} + \frac{A_y}{A}\hat{j}$

$\hat{A} = \sin\alpha\,\hat{i} + \cos\alpha\,\hat{j}$

- Direction of the resultant vector is determined by

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right)$$

- For any number of vectors the magnitude of the resultant

$$R = \sqrt{(A_x + B_x + C_x + \ldots\ldots\ldots)^2 + (A_y + B_y + C_y + \ldots\ldots\ldots)^2}$$

$$\theta = \tan^{-1}\left(\frac{A_y + B_y + C_y + \ldots\ldots}{A_x + B_x + C_x + \ldots\ldots}\right)$$

S (Sine positive)	A (All positive)
T (Tan positive)	C (Cos positive)

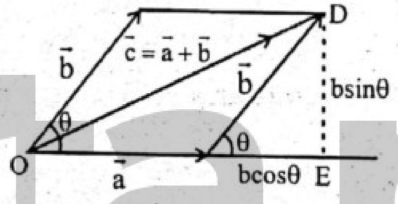
- Remember following diagram-

  Keeping in mind the conventions for measuring angle of resultant vector, you can calculate the angle using the table below: -

Situation	Quadrant	Angle calculated	Angle calculated according to conventions.
$R_x \rightarrow$ Positive $R_y \rightarrow$ Positive	1st	$\phi = \tan^{-1}\left\lvert\frac{R_y}{R_x}\right\rvert$	$\theta = \phi$
$R_x \rightarrow$ Negative $R_y \rightarrow$ Positive	2nd	$\phi = \tan^{-1}\left\lvert\frac{R_y}{R_x}\right\rvert$	$\theta = 180^\circ - \phi$
$R_x \rightarrow$ Negative $R_y \rightarrow$ Negative	3rd	$\phi = \tan^{-1}\left\lvert\frac{R_y}{R_x}\right\rvert$	$\theta = 180^\circ + \phi$
$R_x \rightarrow$ Positive $R_y \rightarrow$ Negative	4th	$\phi = \tan^{-1}\left\lvert\frac{R_y}{R_x}\right\rvert$	$\theta = -\phi$ or $\theta = 360^\circ - \phi$

PARALLELOGRAM LAW

- This law is applicable only when tails of two vectors are at same point.
- In case of parallelogram law from two co-initial vectors we should make a parallelogram whose diagonal represents the resultant of these two vectors.



- Using Phytagorous theorem in right angled triangle DOE: We get:

$$c^2 = (a + b\cos\theta)^2 + (b\sin\theta)^2$$

$$c^2 = a^2 + b^2\cos^2\theta + 2ab\cos\theta + b^2\sin^2\theta = a^2 + b^2(\cos^2\theta + \sin^2\theta) + 2ab\cos\theta \quad \therefore \cos^2\theta + \sin^2\theta = 1$$

$$c^2 = a^2 + b^2 + 2ab\cos\theta \quad \text{OR} \quad c = \sqrt{a^2 + b^2 + 2ab\cos\theta}$$

- $|\vec{c}| = \sqrt{a^2 + b^2 + 2ab\cos\theta}$

  If a (magnitude of $\vec{a}$) and b (magnitude of $\vec{b}$) are constant and θ varies then c will also vary because cos θ varies.

  c will be maximum when $\cos\theta = +1$ i.e. $\theta = 0^\circ$.

  Thus $c_{max} = \sqrt{(a+b)^2}$ or $c_{max} = |\vec{a} + \vec{b}|$

  c will be minimum when $\cos\theta = -1$ i.e., $\theta = 180^\circ$. Thus,

  $c_{min} = \sqrt{(a-b)^2}$ or $c_{min} = |\vec{a} - \vec{b}|$

  Hence, resultant of two vectors $\vec{a}$ and $\vec{b}$ can vary between c_{max} and c_{min}

- **For subtraction**

  $|\vec{c}| = \sqrt{a^2 + b^2 - 2ab\cos\theta}$

SCALAR OR DOT PRODUCTS

If product of two vectors is a scalar, then it is called scalar product or dot product.

$\vec{A}.\vec{B} = AB\cos\theta.$

Example of dot product

Work (scalar quantity) is dot product of force and displacement vector.

Characteristics of scalar product

Let us consider two vectors $\vec{A}$ and $\vec{B}$ to elaborate characteristics.

Scalar product holds commutative law i.e.

$\vec{A}.\vec{B} = \vec{B}.\vec{A}$

- It holds association law i.e.

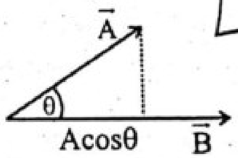
  $m\vec{A}.n\vec{B} = n\vec{A}.m\vec{B} = mn\vec{A}.\vec{B}$ (m and n are numbers)
- If $\vec{A}.\vec{B} = 0$ means θ=90° or $|\vec{A}| = 0$ or $|\vec{B}| = 0$ or both vectors are zero vectors.
- For unit vectors $\hat{i}, \hat{j}, \hat{k}$

  $\hat{i}.\hat{j} = \hat{j}.\hat{k} = \hat{k}.\hat{i} = 0$ and $\hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1$.
- To find angle between two vector to be multiplied.

  $$\theta = Cos^{-1}\left(\frac{A_xB_x + A_yB_y + A_zB_z}{AB}\right)$$
- *The result of product of two equal vectors is equal to the square of their magnitude. (Self scalar product).*

  $\vec{A}.\vec{A} = A^2$.

DO YOU KNOW THIS



Component of $\vec{A}$ along $\vec{B}$ is

$A\cos\theta = \vec{A}.\hat{B}$

Do You Know?

Scalar product of two parallel vectors is equal to the product of their magnitudes only.

POINT TO PONDER

Is a Current (I) scalar quantity or Vector quantity?

VECTOR OR CROSS PRODUCT

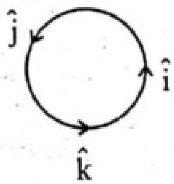
If product of two vectors is a vector, then it is called vector product

$$\vec{A}\times\vec{B} = AB\sin\theta\,\hat{n}$$

where $\hat{n}$ is normal to the plane containing vectors $\vec{A}$ and $\vec{B}$.

Characteristics of vector product

- Cross product does not obeys commutative law
- $\vec{A}\times\vec{B} \neq \vec{B}\times\vec{A}$
- $\vec{A}\times\vec{A} = \vec{0}$, therefore, $\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = \vec{0}$
- $\vec{A}\times\vec{B} = AB\,\hat{n}$ if θ = 90°, therefore, $\hat{i}\times\hat{j} = \hat{k}$, $\hat{j}\times\hat{k} = \hat{i}$,, $\hat{k}\times\hat{i} = \hat{j}$
- $m(\vec{A}\times\vec{B}) = (m\vec{A})\times\vec{B} = \vec{A}\times(m\vec{B})$
- $\vec{A}\times\vec{B} = \vec{0}$ if $\vec{A}$ and $\vec{B}$ are parallel or anti-parallel vectors.
- If the direction of any vector is reversed cross product becomes negative.



- If both vectors are reversed no change in cross product occurs.
- $\vec{A}\times\vec{B}=(A_yB_z-B_yA_z)\hat{i}+(A_zB_x-B_zA_x)\hat{j}+(A_xB_y-B_xA_y)\hat{k}$

OR

$$\vec{A}\times\vec{B}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ A_x & A_y & A_z\\ B_x & B_y & B_z\end{vmatrix}$$

DO YOU KNOW?

The vector product of two vectors gives the area of parallelogram.

- Scalar triple product gives volume of parallelepiped.

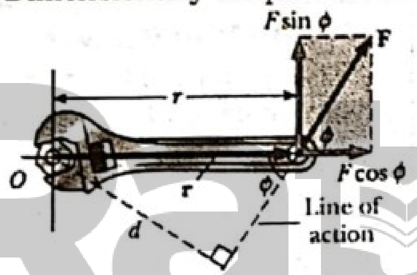
$\vec{A}\cdot\left(\vec{B}\times\vec{C}\right)=A_x(B_yC_z-C_yB_z)-A_y(B_xC_z-C_xB_z)+A_z(B_xC_y-C_xB_y)$

OR $\vec{A}\cdot\left(\vec{B}\times\vec{C}\right)=\begin{vmatrix}A_x & A_y & A_z\\ B_x & B_y & B_z\\ C_x & C_y & C_z\end{vmatrix}$

TORQUE

A physical quantity, which produces angular acceleration, is called torque.

- Dimensionally torque resembles with work.



DO YOU KNOW?

An inclined door automatically closes due to the torque produced by horizontal component of its weight.

- Torque is a vector quantity. $\vec{\tau}=\vec{r}\times\vec{F}=rF\sin\phi\ \hat{n}$
- Magnitude of torque is given as;

$\tau = rF\sin\phi$

$\tau = rF$ if $\phi = 90°$

- SI unit of torque is Nm.
- Torque is rotational analogue of force.
- Following factors affect torque:

(i) Magnitude of force

(ii) Magnitude of position vector or distance between the line of action of force and pivot point

(iii) Sine value of angle θ between $\vec{F}$ and $\vec{r}$.

- If line of action of force $\overrightarrow{F}$ passes through axis of rotation, then no torque is produced.
- $\tau = rF\sin\theta$

OR $\tau = (r\sin\theta)F$.

$\tau = r_\perp F$

Where $r_\perp$ is component of position vector perpendicular to force and

$r_{\perp} = r\sin\theta$ is called *moment arm of torque.*

OR $\tau = r\,(F\sin\theta)$

$\tau = r\,F_{\perp}$

Which shows that only perpendicular component of force contributes to torque and horizontal component does nothing in case of torque.

- If $\theta = 0°$ or π then $r_{\perp} = 0$ m and $F_{\perp} = 0$N so that $\tau = 0$ Nm.

Direction alterations

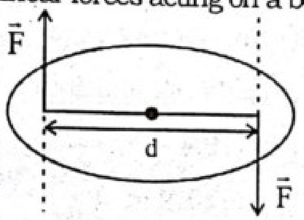
(a) If $\vec{F}$ is reversed, then direction of torque is also reversed.

(b) If $\vec{r}$ is reversed, then direction of torque is also reversed.

(c) If both $\vec{r}$ and $\vec{F}$ both are reversed then the direction of torque remains unchanged.

COUPLE

Two equal, opposite and non-collinear forces acting on a body constitute a couple.

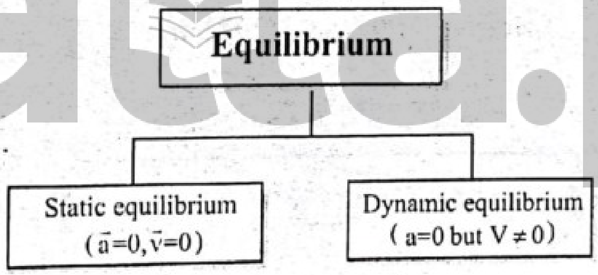


- Torque of a couple is never zero and $\tau = Fd$ where d = moment arm of couple.

EQUILIBRIUM

If a body keeps its state of rest or uniform motion invariant under many forces, it is said to be in perfect equilibrium.

KINDS OF EQUILIBRIUM



CONDITIONS OF EQUILIBRIUM

The conditions of equilibrium can be stated in terms of coplanar forces as follow:-

1st Condition of Equilibrium

The sum of forces acting on a body is equal to zero.

i.e. $\Sigma\vec{F} = 0$

For coplanar forces

$\Sigma\vec{F}_x = 0$ and $\Sigma\vec{F}_y = 0$

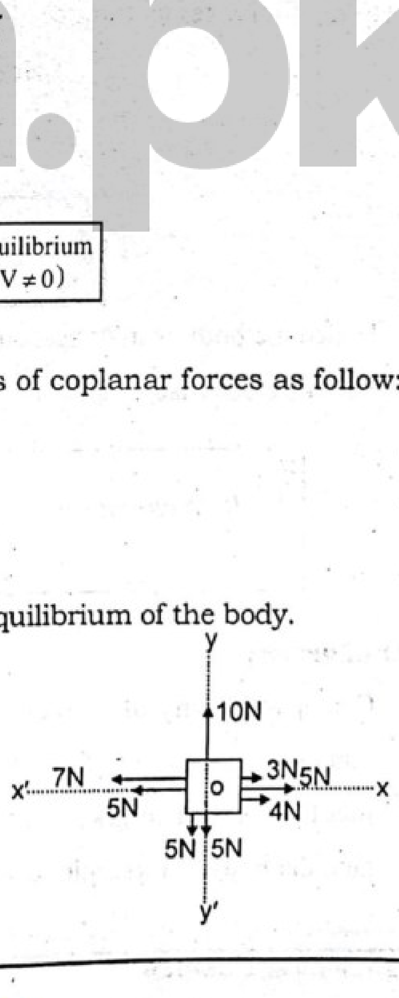
- 1st condition of equilibrium controls the translational equilibrium of the body.

Explanation: Consider a body under the action of the external forces as shown in the diagram.

Take forces along positive x-axis as positive and along as negative. Similarly for Y-axis Sum (resultant) of forces along x-axis = ΣF_x

ΣF_x = $5N + 3N + 4N - 7N - 5N$ = zero

Sum (resultant) force along y-axis = ΣF_y



ΣF_y = 10N – 5N – 5N = zero

Sum of all the external forces on the body i.e ΣF is zero, hence the body is in the first condition of equilibrium (Σ = Sigma = Sum)

2nd Condition of Equilibrium

The sum of torques acting on a body about the same axes of rotation is equal to zero. Mathematically $\Sigma \vec{\tau} = 0$

Or

Sum of anticlockwise torques = sum of clockwise torques

- 2nd condition of equilibrium controls the rotational equilibrium of the body.

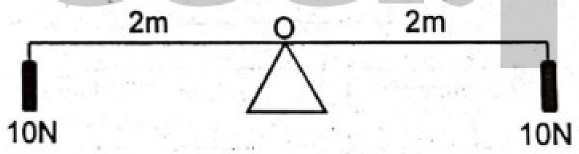
Explanation: consider a body with axis of rotation O under the action of external torques as shown in the Fig. The clockwise torque is taken –ve and anticlockwise torque is taken +ve.

Clockwise torque = 10N × 2m
= –20 N m

Anticlockwise torque = 10N × 2m
= 20N m

Sum of all external torques = $\Sigma\tau$

$\Sigma\tau$ = 20 N m – (20 N m)
= zero



Hence the body is in the second condition of equilibrium. In such cases:

Sum of clockwise torques = Sum of anticlockwise torques

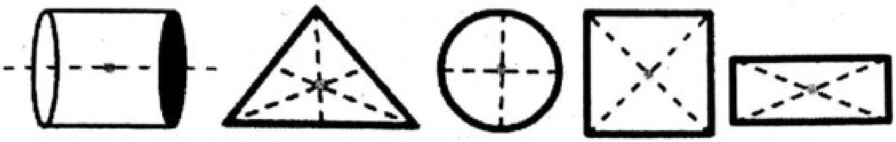
> **DO YOU KNOW?**
> *Both conditions of equilibrium must be fulfilled for a body to be in complete equilibrium.*

Center of gravity

Center of gravity of a body is a point where total weight of the body is concentrated. Every body posses a center of gravity and this is irrespective of shape of the body. It is not necessary that the center of gravity should be within the body, but it may also be situated in space out side the body. Example: center of gravity of a ring is at the center, which is in the space.

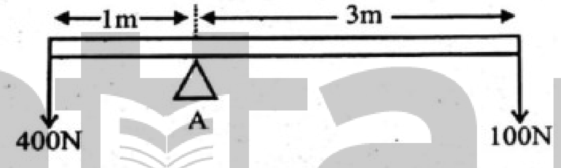
Center of gravity of different objects:

- **Rectangle:** Center of gravity of a rectangle is at the point of intersection of its diagonals
- **Circle:** Center of gravity of a circle is at its center.
- **Square:** Center of gravity of square is at the point of intersection of its diagonals.
- **Regular bar:** The center of gravity of a regular bar is at its geometrical center.
- **Triangle:** The center of gravity of a triangle is at the point of intersection of its medians.
- **Cylinder:** The center of gravity of a cylinder is at the axis of cylinder.



CHOOSE THE CORRECT OPTION

A uniform rod loaded as shown in the fig. below is pivoted at the point A so that it is in equilibrium. The weight of the rod will be



(a) 700N (b) 300N (c) 500N (d) 100N

(1) **Rectangular coordinate system is also called**

(a) polar coordinate system
(b) Cartesian coordinate system
(c) cylindrical coordinate system
(d) spherical coordinate system

(2) **The direction of a vector in space is specified by**

(a) one angle
(b) two angle
(c) three angle
(d) no angle

(3) **Addition of vectors obey**

(a) commutative law
(b) distributive law
(c) associative law
(d) all given laws in a, b and c

(4) **Which of the following statement is correct about force and velocity**

(a) force and velocity both are scalars
(b) force and velocity both are vectors
(c) Force is scalar and velocity is vector
(d) force is vector and velocity is scalar

(5) **A vector S of magnitude 6 and another vector T have a sum of magnitude 12. The vector T:**

(a) may have a magnitude of 20
(b) must have a magnitude of at least 6 but no more than 18
(c) must be perpendicular to $\vec{S}$
(d) must be perpendicular to the vector T

(6) **$\text{Cos}\theta\,\hat{i} + \text{Sin}\theta\,\hat{j}$ is a**

(a) vector
(b) position vector
(c) vector in the direction at angle θ with x-axis
(d) unit vector in the direction at angle θ with x-axis

(7) **Maximum number of rectangular components are**

(a) one
(b) two
(c) three
(d) infinite

(8) **Maximum number of components of a vector may be**

(a) one
(b) two
(c) three
(d) infinite

(9) **Which one is not correct for a vector $\vec{A} = \sqrt{2}\hat{i} + \sqrt{2}\hat{j}$**

(a) has direction θ=45° with x-axis
(b) has magnitude 2
(c) has magnitude 2 and direction θ=45° with y-axis
(d) has magnitude –2

(10) **The resultant of two forces of equal magnitudes is also equal to the magnitude of the forces. The angle between the two forces is**

(a) 30°
(b) 60°
(c) 90°
(d) 120°

(11) If $|\vec{A}+\vec{B}|^2 = A^2 + B^2$, then

$R^2 = A^2 + B^2$

$R = \sqrt{A^2 + B^2}$

$\theta = 46$

(a) $\vec{A}$ and $\vec{B}$ must be parallel and in the same direction

(b) the angle between $\vec{A}$ and $\vec{B}$ must be 90°

(c) $\vec{A}$ and $\vec{B}$ must be parallel and in opposite directions

(d) none

(12) If $|\vec{A}-\vec{B}| = A + B$ and neither $\vec{A}$ nor $\vec{B}$ vanish, then

(a) $\vec{A}$ and $\vec{B}$ are parallel and in the same direction

(b) the angle between $\vec{A}$ and $\vec{B}$ is 60°

(c) $\vec{A}$ and $\vec{B}$ are parallel and in opposite directions

(d) $\vec{A}$ is perpendicular to $\vec{B}$

(13) **Two vectors A and B are making angle θ with each other. The scalar projection of vector B on vector A is written as**

(a) $\frac{\vec{A}.\vec{B}}{A}$ (b) $\frac{\vec{A}.\vec{B}}{B}$

(c) A.cos θ (d) both a and b are correct

(14) **Two vectors are** $\vec{A} = 3\hat{i}+2\hat{j}-\hat{k}$ **and** $B = -3\hat{i}-2\hat{j}+\hat{k}$ **then**

(a) $\vec{B}$ is anti parallel to $\vec{A}$ (b) $\vec{B}$ is inclined at 60° with $\vec{A}$

(c) $\vec{B}$ has negative magnitude (d) B is perpendicular to $\vec{A}$

(15) Let $\vec{V} = (2.00m)\hat{i} + (6.00m)\hat{j} - (3.00m)\hat{k}$. The magnitude of $\vec{V}$ is

(a) 5.00m (b) 5.57m

(c) 7.00m (d) 7.42m

(16) **Vectors $\vec{A}$ and $\vec{B}$ each have magnitude L. When drawn with their tails at the same point, the angle between them is 30°. The value of $\vec{A}\cdot\vec{B}$ is:**

(a) $2L^2$ (b) $\frac{\sqrt{3}L^2}{2}$

(c) L^2 (d) zero

(17) **Which one is not a correct relation?**

(a) $\vec{A}\times\vec{B} = \vec{A}\times\vec{B}$ (b) $|\vec{A}\times\vec{B}| = -|\vec{B}\times\vec{A}|$

(c) $\vec{A}\times\vec{B} = AB\sin\theta\hat{n}$ (d) $\vec{B}\times\vec{A} = AB\sin\theta(-\hat{n})$

(18) **The value of $\hat{i}\bullet(\hat{j}\times\hat{k})$**

(a) 0 (b) 3

(c) +1 (d) -1

(19) **Resultant of which of the following may be equal to zero ?**

(a) 10 N, 10 N, 35 N (b) 10 N, 10N, 25 N

(c) 10N, 10N, 10N (d) none of these

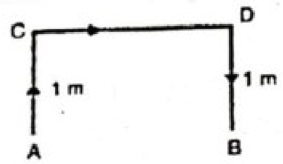
(20) **Null vector is a vector which has**

(a) zero magnitude
(b) no specified direction
(c) both a and b are correct
(d) both a and b are not correct

(21) **Which one is a unit vector?**

(a) $\sqrt{3}\hat{i}+\sqrt{3}\hat{j}+\sqrt{3}\hat{k}$
(b) $\frac{1}{\sqrt{3}}\hat{i}+\frac{1}{\sqrt{3}}\hat{j}+\frac{1}{\sqrt{3}}\hat{k}$
(c) $\frac{\sqrt{3}}{3}\hat{i}+\frac{\sqrt{3}}{3}\hat{j}+\frac{\sqrt{3}}{3}\hat{k}$
(d) both b and c are correct

(22) **A man walks from A to C , C to D and D to B (as shown in figure). The magnitude of displacement of man is 10 m. The total distance travelled by the man is :**



(a) 10m
(b) 12m
(c) 7m
(d) 2m

(23) **The magnitude of cross product of two vectors is equal to the dot product between them. The angle between the two vectors is**

(a) 30°
(b) 45°
(c) 60°
(d) 180°

(24) **An airplane flies 400m due north and then flies 300m south and then flies 1200m upwards. The net displacement is**

(a) 1500m
(b) 1200m
(c) 900m
(d) 700m

(25) **A child takes 8 steps towards east and 6 steps towards north. If each step is equal to 1 cm, then the magnitude of displacement is:**

(a) 14m
(b) 0.1m
(c) 12m
(d)0.01m

(26) **For a body to be in equilibrium under the combined action of several forces:**

(a) all the forces must be applied at the same point
(b) all of the forces form pairs of equal and opposite forces
(c) any two of these forces must be balanced by a third force
(d) the sum of the components of all the forces in any direction must equal zero

(27) **Torque acting on a body determines**

(a) acceleration
(b) linear acceleration
(c) angular acceleration
(d) direction of motion of the body

(28) **The dimension of torque**

(a) $[MLT^{-1}]$
(b) $[ML^2T^{-1}]$
(c) $[ML^2T^{-2}]$
(d) $[ML^2T]$

(29) **A body will be in complete equilibrium when it is satisfying**

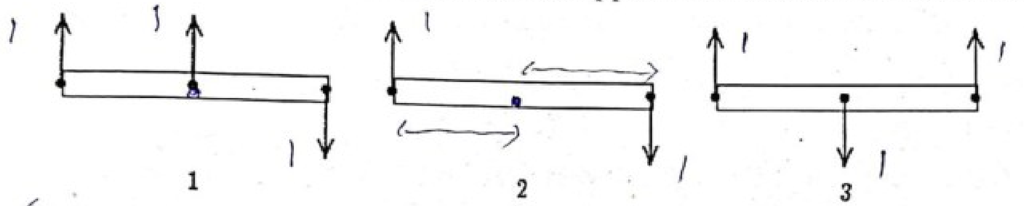
(a) Ist condition of equilibrium

(b) 2nd condition of equilibrium

(c) both 1^{st} and 2^{nd} condition of equilibrium

(d) impossible

(30) **Three identical uniform rods are each acted upon by two or more forces, all perpendicular to the rods and all equal in magnitude. Which of the rods could be in static equilibrium if an additional force is applied at the center of mass of the rod?**



(a) Only 2 (b) Only 1

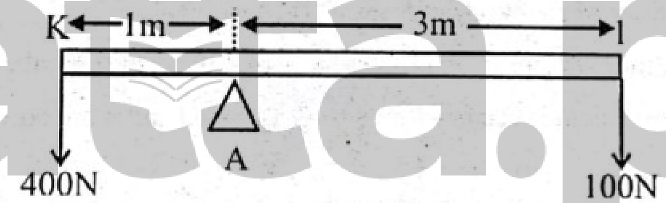
(c) Only 3 (d) Only 1 and 2

(31) **Three coplanar forces acting on a body keep it in equilibrium. They should therefore be**

(a) concurrent (b) non concurrent

(c) parallel (d) non parallel

(32) **A uniform rod loaded as shown in the fig. below is pivoted at the point A so that it is in equilibrium. The weight of the rod will be**



(a) 700N (b) 300N

(c) 500N (d) 100N

(33) **A central force is that which**

(a) can produce torque

(b) can't produce torque

(c) some time can produce torque some time can't

(d) has no relation with torque

(34) **It is easier to turn a steering wheel with both hands than with a single hand because**

(a) accelerating force increases on the wheel

(b) two forces act on the wheel

(c) two hands provide firm grip

(d) couple acts on the wheel

(35) **A force of 10N is acting along y-axis. Its component along x-axis is**

(a) zero (b) 10N

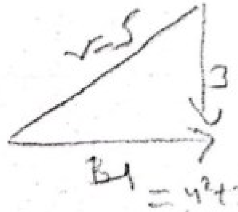
(c) 100N (d) 5N

(36) **The unit vector in the direction of vector $\vec{A} = 2\hat{i} - 2\hat{j} + \hat{k}$ is**

(a) $\dfrac{2\hat{i} - 2\hat{j} + \hat{k}}{2}$ (b) $\dfrac{2\hat{i} - 2\hat{j} + \hat{k}}{9}$

(c) $\dfrac{2\hat{i} - 2\hat{j} + \hat{k}}{3}$ (d) $\dfrac{2\hat{i} - 2\hat{j} + \hat{k}}{5}$

(37) **A man moves on a cycle with a velocity of 4km/h. the rain appears to fall upon him with a velocity of 3km/h vertically. The actual velocity of the rain is**



$= 4^2+3^2$
$= 25 = 5$

(a) 7km/h (b) 5 km/h

(c) 10 km/h (d) 15 km/h

(38) **In which quadrant only, value of 'tan' will be positive?**

(a) first (b) second

(c) third (d) both 1st and 3rd

(39) **If $\vec{A} = A_x\,\hat{i} + A_y\,\hat{j} + A_z\,\hat{k}$ and $\vec{B} = B_x\,\hat{i} + B_y\,\hat{j} + B_z\,\hat{k}$ then**

(a) $\vec{A} \cdot \vec{B} = A_xB_x + A_yB_y + A_zB_z$ (b) $\vec{A} \cdot \vec{B} = A_xB_y + A_yB_z + A_zB_y$

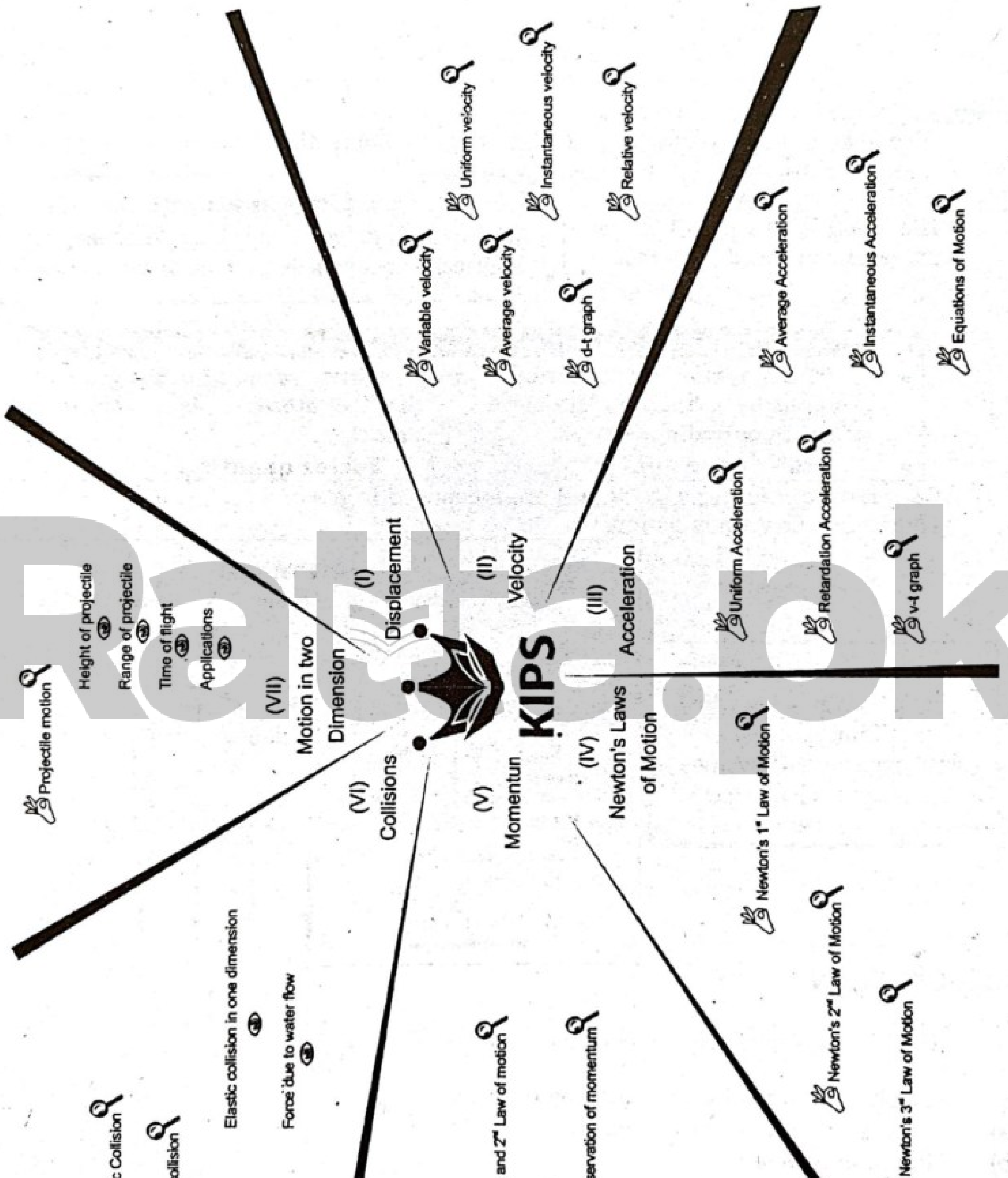
(c) $\vec{A} \cdot \vec{B} = A_yB_z + A_zB_y + A_zB_x$ (d) $\vec{A} \cdot \vec{B} = A_xB_z + A_yB_y + A_zB_x$

(40) **The cross product of two vectors is zero when**

(a) they are parallel vectors (b) they are anti parallel vectors

(c) they are perpendicular vector (d) both a and b are correct

Chapter 3 MOTION AND FORCE



INTRODUCTION

The concept of state of motion and rest are described relative to the observer.

- If a body does not change its state w.r.t surroundings, it is in the state of rest.
- If a body changes its state w.r.t surroundings, then it is in the state of motion.

> A moving body can posses both states of rest and motion, depending on the observer.

DISPLACEMENT

Displacement is a vector that depicts the change in the position of body from initial to final position.

DISTANCE

The length of the path between two points is called distance.

> **Do you know?**
> When a body moves along straight line then the displacement coincides with the distance traveled.

SPEED	VELOCITY
• **The ratio of distance covered by a body to the time taken is called speed.**	• **Time rate of change of displacement is called velocity.**
• **Scalar quantity.**	• **Vector quantity.**

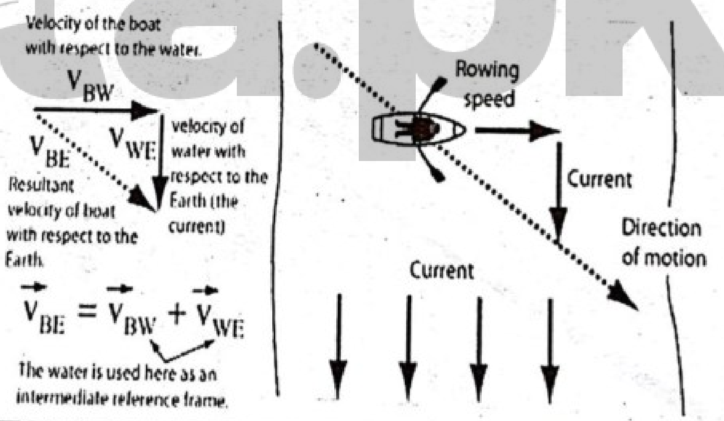
Both have dimensions $[LT^{-1}]$ and are measured in ms^{-1}

Their classification is as follow:-

> **Do you know?**
> For a body moving with uniform speed, Its instantaneous and average speeds are equal to each other.

Information

A boat in current is a good example of relative velocity.



ACCELERATION

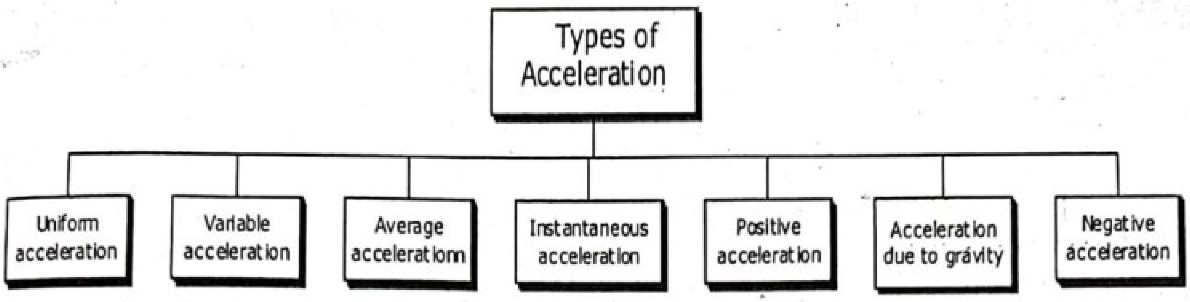
Rate of change of velocity is called acceleration. $a = \frac{\overrightarrow{\Delta v}}{\Delta t}$

- Acceleration may be produced by the variation of:

(a) magnitude of velocity i.e. speed

(b) direction of velocity

(c) both magnitude and direction of velocity.



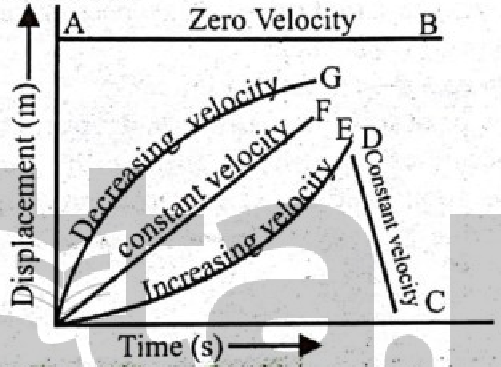
- *Acceleration is a vector quantity measured in ms^{-2}. Its dimensions are $[LT^{-2}]$*
  If the velocity of body reduces but not to zero, then negative acceleration is called **deceleration** but if the velocity reduces to zero, then negative acceleration is called **retardation.**

GRAPHS

Graph is a pictorial display between two dependent quantities.

Displacement-Time Graph

A graph between displacement and time is called displacement-time graph. From such a graph as show in Fig. we observe



(i) If the graph is straight line (AB) parallel to x-axis, it shows there is no displacement with time or body has zero velocity.

(ii) If it is a straight line inclined to x-axis such as OF, it shows the body is moving with a constant velocity. If this straight line is inclined to x-axis by an angle > 90° (such as CD) it shows body is moving with negative velocity. We can not have straight line parallel to y-axis as it will indicate infinite velocity.

(iii) If the graph is such that its slope keeps on increasing with time (such as OE), the velocity increasing i.e. the motion is accelerated.
If the graph is such that its slope keeps on decreasing with time such as OG, the velocity is decreasing.

Velocity-Time Graph

A graph plotted between velocity and time is known as velocity-time graph. The shape of graph indicates nature of acceleration as shown in Fig. given below

Salient Features

- The slope of velocity time graph gives acceleration i.e.

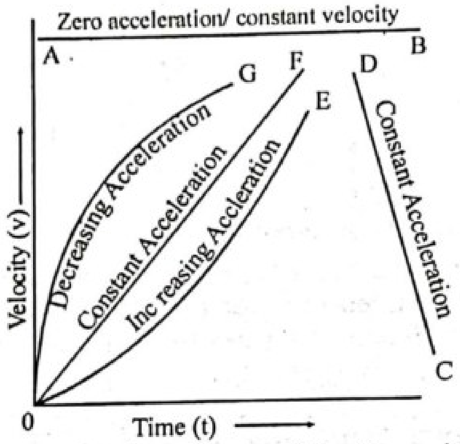
$$\vec{a} = \frac{\Delta \vec{V}}{\Delta t} = \tan\theta = \text{Slope of graph.}$$

(i) Curve AB indicates body is moving with a constant velocity having no acceleration.

(ii) Curve like CD indicates body is moving with constant acceleration but retarded (angle with x-axis > 90).

(iii) Curve like OF where angle < 90 represents constant acceleration accelerated.

(iv) Curve like OG where slope decreases with time it corresponds to decreasing acceleration.



(v) Curve like OE where slope increases with time it corresponds to increasing acceleration.

Some Important Points

- If a body is moving with constant velocity then acceleration (or force on the body) is zero.
- The slope of d – t graph gives velocity.
- The slope of v – t graph gives acceleration.
- If a body falls freely or starts from rest or is dropped $v_i = 0$.
- The velocity and acceleration need not to be in the same direction.
- Velocity and acceleration need not to be zero simultaneously.
- When a body performs journey in two parts of equal distance with speed v_1 and v_2 then average speed $v_{av} = \frac{2v_1v_2}{v_1+v_2}$
- When a body performs journey in two parts of equal time with speed v_1 and v_2 then average speed $= \frac{v_1+v_2}{2}$
- If the body is thrown upward then it will rise until its velocity becomes zero and will rise to a height $h = \frac{v^2}{2g}$
- If a body travels with a uniform acceleration a_1 for a time interval t_1 and with uniform acceleration a_2 for time interval t_2, then the average acceleration $a = \frac{a_1t_1+a_2t_2}{t_1+t_2}$
- A body thrown upwards takes same time for going up (till its velocity becomes zero) as it takes to come down and comes back with the same velocity with which it was throw upward.
- When a body is dropped freely from the top of building and another body is projected horizontally from the same point, both will reach the ground at the same time.
- Time taken to reach earth by a freely falling body from the same height is independent of mass (neglecting air effects).
- For a body projected upwards, the magnitude of velocity at any point in its path is same whether the body is moving upwards or downwards.

EQUATIONS OF MOTION(BY GALILEO)

$V_f = V_i + at$ or $V_f = V_i + gt$

$S = V_i t + \frac{1}{2}at^2$ or $S = V_i t + \frac{1}{2}gt^2$

$V_f^2 = V_i^2 + 2aS$ or $V_f^2 = V_i^2 + 2gS$

- Distance traveled in nth second with constant acceleration is $S_n = V_i + \frac{1}{2}a(2n-1)$

NEWTON'S LAWS OF MOTION

- Newton's work on physics in his book named ***PRINCIPIA of mathematics***.
- Newton's laws applicable for moving objects having speed not comparable to the speed of light.

1st law (law of inertia)

First Law of Motion (Law of Inertia): It states that every body continues to be in state of rest or of uniform motion along a straight line unless it is compelled to change that state by an applied force.

- This law qualitatively defines the force.
- The inability of the body to change its state is called inertia. So, it is also known as the law of inertia of Galileo.
- Inertia resists change in the state of motion of the body.

Second Law of Motion (Force and Acceleration): The effect of an applied force on a body is to cause it to accelerate in the direction of the force. The acceleration is in direct proportion to the force and is inversely proportional to the mass of the body.

OR

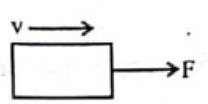
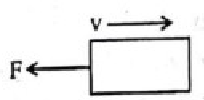
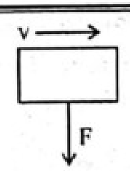
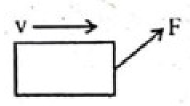
A force F acting on a body is equal to its change in momentum per second

$F \propto$ Mass of the body x Change in velocity per second $\propto ma$

$\therefore$ $F = k\,ma$ (where k is a constant)

But $k = 1$ $\therefore$ $\mathbf{F = ma}$

- Weight: The weight of a body is equal to the force with which the body is attracted by the earth towards its center.

When force acts in direction of velocity	When force acts opposite to direction of velocity	When force acts perpendicular to direction of velocity	When force acts at some angle to the direction of velocity
			
Speed increases and direction of motion remain same	Speed decreases and direction of motion remain same	Only direction changes and magnitude of velocity remain same	Both magnitude and direction of velocity changes

3rd law: $\vec{F}_{AB} = -\vec{F}_{BA}$ or $\vec{F}_{action} = -\vec{F}_{reaction}$

Action and reaction forces never acts on the same body.

Inertial Frame

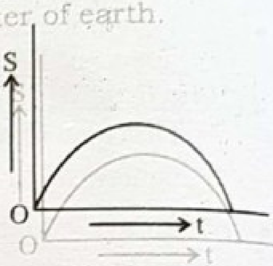
It is the frame in which the body is at rest or moving with uniform relative velocity. Law of inertia hold in these frames. $(\vec{a}=0)$.

Non Inertial Frame

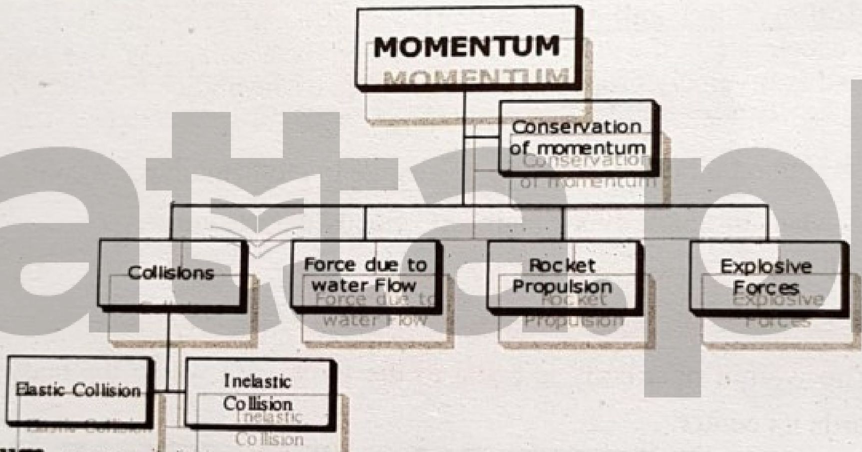
It is the frame which is not moving with uniform relative velocity. Law of inertia not hold in these frames. $(\vec{a}\neq 0)$.

Applications

- Weight is a force with which a body is attracted towards the center of earth.
- Earth is an approximate inertial frame of reference because it has small negligible angular acceleration.
- In zero force environment only inertial observer can sit.
- Swimming in a water pond.
- Driving a car on road.
- Mass measurement independent of gravity.
- Displacement – time graph of $S=v_i t+\frac{1}{2}at^2$ is a parabola as shown below.



MOMENTUM



Linear momentum

"The idea of linear momentum was introduced by Newton who defined it as product of mass and velocity of an object". $\vec{p}=m\vec{v}$

- Linear momentum is a vector pointing along velocity
- Linear momentum depends upon $\vec{p}\ \alpha\ \vec{v}$ $\quad \vec{p}\ \alpha\ m$
- $\vec{p}=0$ if $\vec{v}=0$, how massive the body may be.
- *SI unit of linear momentum are kg ms⁻¹ or Ns. Dimension of momentum are **[MLT⁻¹]***

Impulse

We define impulse of force as; "The product of force and its duration of application"

$\vec{I}=\Delta\vec{p}=\vec{F}.\Delta t$

- Dimensionally $\vec{I}$ is same that of linear momentum.
- Inertial mass is quantitative measurement of acceleration produced.
- Time rate of change of momentum is equal to the applied force.

POINT PONDER 70

The thermopore pieces inside the dinner sets protect the cups or other items from fracturing. Why?

Change in momentum is equal to the impulse of the body.

Law of conservation of linear momentum

In an ***isolated*** *system* $(P_i)_{total} = (P_f)_{total}$

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$$

- The total linear momentum of an isolated system remains constant.

COLLISIONS

Collision is said to be taken place if some sort of interaction appears between bodies due to their closeness.

COLLISIONS

- *Elastic collisions (K.E and linear momentum both are conserved)*
- *Inelastic collisions (only linear momentum is conserved)*

Elastic collision in one dimension

- Elastic collision in one dimension is that one, in which colliding bodies do not deviate from their line of motion, after the collision.
- In case of two bodies undergoing elastic collision in one dimension, we have

$$V_1 + V_1' = V_2 + V_2' \quad \text{or} \quad V_1 - V_2 = -(V_1' - V_2')$$

Speed of approach = Speed of recession

After collision,

$$V_1' = \frac{(m_1 - m_2)V_1}{(m_1 + m_2)} + \frac{2m_2V_2}{(m_1 + m_2)}$$

$$V_2' = \frac{2m_1V_1}{(m_1 + m_2)} + \frac{(m_2 - m_1)V_2}{(m_1 + m_2)}$$

Cases of elastic collision

Case I:	If	$m_1 = m_2$	&	$V_2 \neq 0$
	then	$V_1' = V_2$	&	$V_2' = V_1$
Case II:	If	$m_1 = m_2$	&	$V_2 = 0$
	then	$V_1' = 0$	&	$V_2' = V_1$

In both cases I & II due to the same masses of the colliding bodies their velocities after collision got interchanged.

Case III:	If	$m_1 >> m_2$	&	$V_2 = 0$
	then	$V_1' = V_1$	&	$V_2' = 2V_1$
Case IV:	If	$m_1 << m_2$	&	$V_2 = 0$
	then	$V_1' = -V_1$	&	$V_2' = 0$

FORCE DUE TO WATER FLOW

Water exerts force on a wall, when impinges over it. This force is equal to the product of mass flow rate of water and its velocity.

i.e. $\vec{F} = \frac{m}{t}\vec{v}$

The above phenomenon gives us an idea to invent turbines that uses hydal energy.

MOMENTUM & EXPLOSIVE FORCES

Conservation of linear momentum decides in which direction, various pieces will fly from an exploding bomb.

- During explosion law of conservation of momentum holds well. The recoil velocity of a rifle (M,V) fired from a bullet (m,v) is $V = -\frac{m}{M}v$
- Recoil velocity is always a fraction of the bullet velocity because M>m.

PROPULSION OF ROCKET

- Propulsion of rocket is according to law of conservation of linear momentum
- **80%** mass of rocket consists of fuel at the launching time.
- A typical rocket consumes about 10,000 Kg fuel in one second.
- Speed of gases expelled from the tail of rocket is over 4000 m/s.
- Instantaneous acceleration in the rocket is $a = mv/M$

  Where

  m = mass of the gases ejected per second

  M = mass of the rocket

  V = velocity of ejected gases

Do you know?

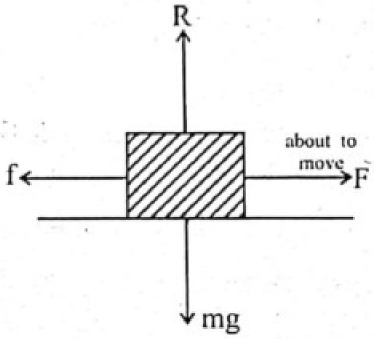
The rockets are made in several compartments. When a compartment is emptied from fuel it is dropped, thus reducing the overall mass of rocket and hence increasing the acceleration of rocket.

FRICTION

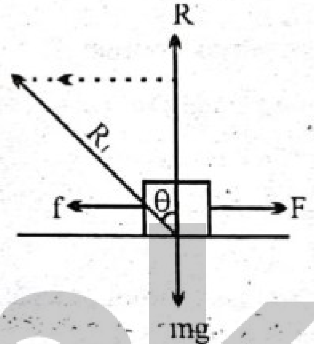
- The property by virtue of which a resisting force is created between two rough bodies which resists the sliding of one body over the other is called friction.
- The force always acts in the direction opposite to that in which the body has a tendency to slide or move.
- The maximum frictional force between two surfaces depends on
  - ✦ Nature of surfaces
  - ✦ Normal contact force
  - ✦ But is independent of the area of contact over wide limits.
- When the body starts moving the force of friction decreases.
- In practice friction can not be zero.
- When we walk on ground then the direction of force of friction is in forward direction because the tendency of slipping is in backward direction.
- Frictional force appears due to interlocking between two surfaces developed due to the molecular irregularities. According to modern view the cause of friction is largely due to atomic and molecular forces of attraction between the two surfaces at the point of contact.

- Coefficient of friction $(\mu) = \dfrac{\text{Limiting friction }(f)}{\text{Normal reaction }(R)}$

or $\mu = \dfrac{f}{R}$ or $f = \mu R$



- The coefficient of friction, depends on, nature of material, surface finish, surface film and temperature.
- For horizontal surface
  $R = mg$
  Then $f = \mu\, mg$
- **Static Friction:** The force of friction that comes into play between two surfaces in contact before the actual motion starts is called static friction.
  Force of Static Friction is given by
  $f_s = \mu_s R$, μ_s is coefficient of static friction



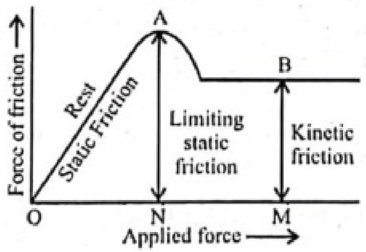
- **Kinetic friction:** when one body moves over the other then the force of friction acting between two surfaces is called kinetic friction.
  Force of kinetic friction is given by
  $f_k = \mu_k R$, μ_k is coefficient of kinetic friction
- **Limiting friction:** The maximum force of friction which comes into play before a body just **begins** to slide over the surface of another body is called limiting friction.
- **Angle of friction** (θ): Angle which the resultant (R_i) of normal reaction (R) and limiting friction (f) make with the normal reaction is called angle of friction.

  From Figure $\tan\theta = \dfrac{f}{R} = \mu$ or $\mu = \tan\theta$

- **For static friction:** $\tan\theta_s = \dfrac{f_s}{R} = \mu_s = \tan\theta_s$
- **For kinetic friction:** $\tan\theta_k = \dfrac{f_k}{R} = \mu_k = \tan\theta_k$
- **Rolling Friction:** When one body rolls over the other body, then the frictional force acting between the two surfaces is called rolling friction.

Note: *For the same two surfaces* $\mu_s > \mu_k > \mu_r$

Graph for frictions

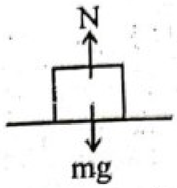
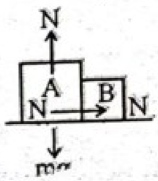
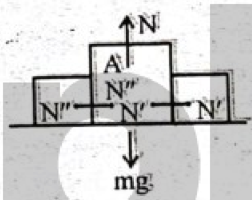
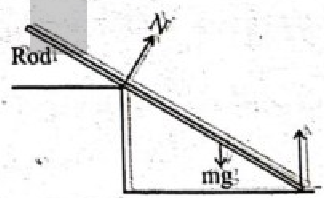
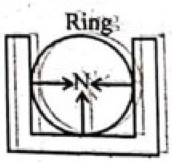
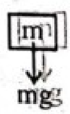


NORMAL CONTACT FORCE

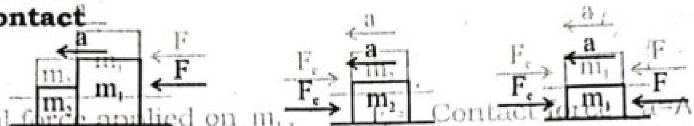
Two bodies are said to be in contact when there is atleast a force perpendicular or parallel to the surface of contact or point of contact which is related to the motion of two bodies.

Chapter-3

- Few contact forces are here:
  - Normal contact force
  - Frictional force
  - Tension in strings
  - Spring force
- Number of contact forces on a body: Total number of normal contact or contact force is equal to the total number of surface of contact or point of contact. Such as:

Normal contact force is single because one surface is in contact.	
Normal contact forces on A are two because two surfaces are in contact.	
Normal contact forces on A are three because three surfaces are in contact	
Normal contact forces on rod are two because two points are in contact	
Normal contact forces on ring are three because three points are in contact.	
Here normal contact force is absent because block is in air, i.e., there is no surface of point of contact.	

1) Masses in Contact

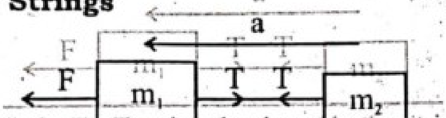


F = Horizontal force applied on m_1, F_c = Contact force, a=Acceleration of the mass

Newton's second law gives: $F - F_c = m_1 a$ and $F_c = m_2 a$

Solving these, we get: $F_c = \dfrac{m_2 F}{m_1 + m_2}$ and $a = \dfrac{F}{m_1 + m_2}$

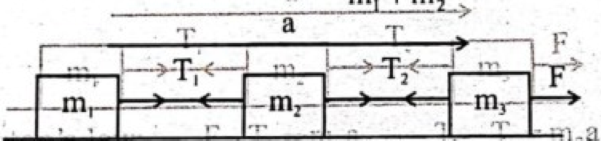
2) Masses Connected by Strings



F = Force by which m_1 is pulled, T = Tension developed in the string, a = Acceleration of the masses

Applying Newton's law: $F - T = m_1 a$, $T = m_2 a$

Solving these, we get: $T = \dfrac{m_2 F}{m_1 + m_2}$ and $a = \dfrac{F}{m_1 + m_2}$



Similarly

Applying Newton's law: $F - T_2 = m_3 a$, $T_2 - T_1 = m_2 a$, $T_1 = m_1 a$

Solving these, we get

$$a = \frac{F}{m_1 + m_2 + m_3}$$

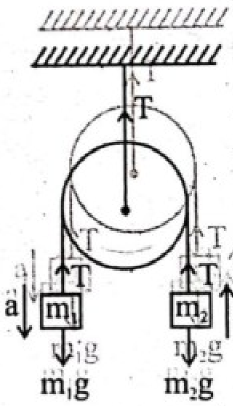
$$T_2 = \frac{(m_1 + m_2)F}{m_1 + m_2 + m_3}$$

$$T_1 = \frac{m_1 F}{m_1 + m_2 + m_3}$$

TENSION AND ACCELERATION IN A STRING

Case 1: Vertical motion of two bodies attached to the ends of string that passes over a frictionless pulley.

Masses Connected by a String passing Over a Pulley: If $m_1 > m_2$, then m_1 will move downwards and m_2 will move upwards, both with the same acceleration a



Applying Newton's second law:

$m_1 g - T = m_1 a$ and $T - m_2 g = m_2 a$

Solving these, we get:

$$a = \frac{m_1 - m_2}{m_1 + m_2} g$$

$$T = \frac{2 m_1 m_2}{m_1 + m_2} g$$

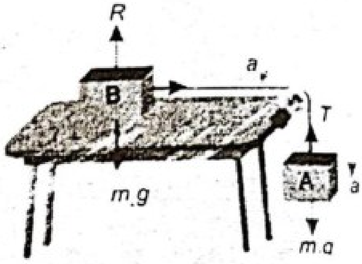
- **Atwood machine:**

  It is an arrangement of two objects of unequal masses. Both objects are attached to the ends of a string and string passes over a frictionless pulley as shown in figure above. It is used to find the acceleration due to gravity

$$g = \frac{m_1 + m_2}{m_1 - m_2} a$$

Case 2:

When one body moves vertically and other moves horizontally:



- **Acceleration:**

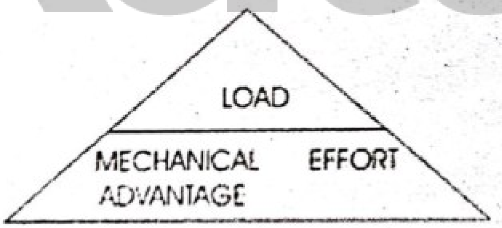
$$a = \frac{m_1 g}{m_1 + m_2}$$

- **Tension:**

$$T = \frac{m_1 m_2 g}{m_1 + m_2}$$

MECHANICAL ADVANTAGE:

Mechanical advantage is defined as the ratio of load to effort.



$$\text{MECHANICAL ADVANTAGE} = \frac{\text{LOAD}}{\text{EFFORT}}$$

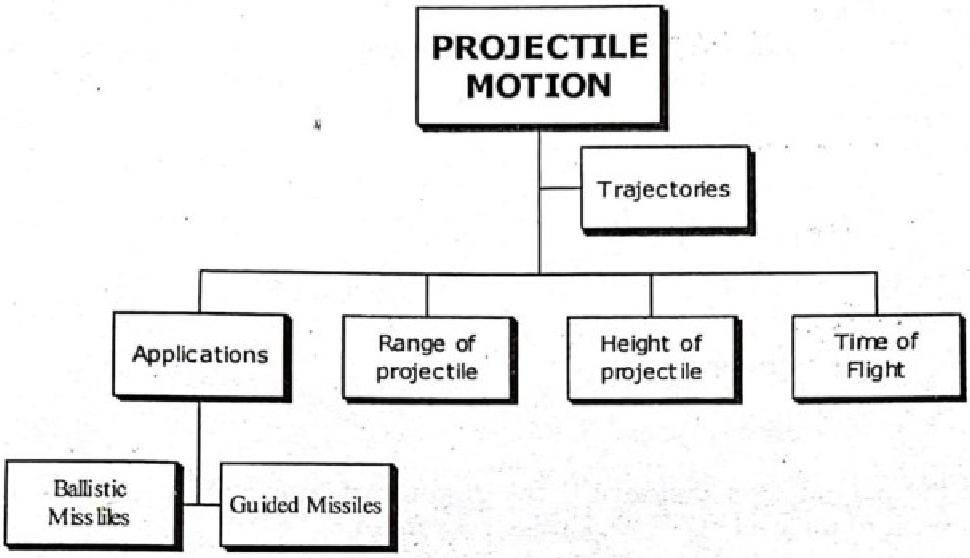
$$\text{LOAD} = \text{MECHANICAL ADVANTAGE} \times \text{EFFORT}$$

$$\text{EFFORT} = \frac{\text{LOAD}}{\text{MECHANICAL ADVANTAGE}}$$

Assumptions for the Derivation of Equations of projectile

- Earth is assumed to be flat over the whole trajectory of projectile.
- The acceleration due to gravity remains constant over the whole trajectory of projectile.
- Neglecting the aerodynamic effects.

PROJECTILE MOTION



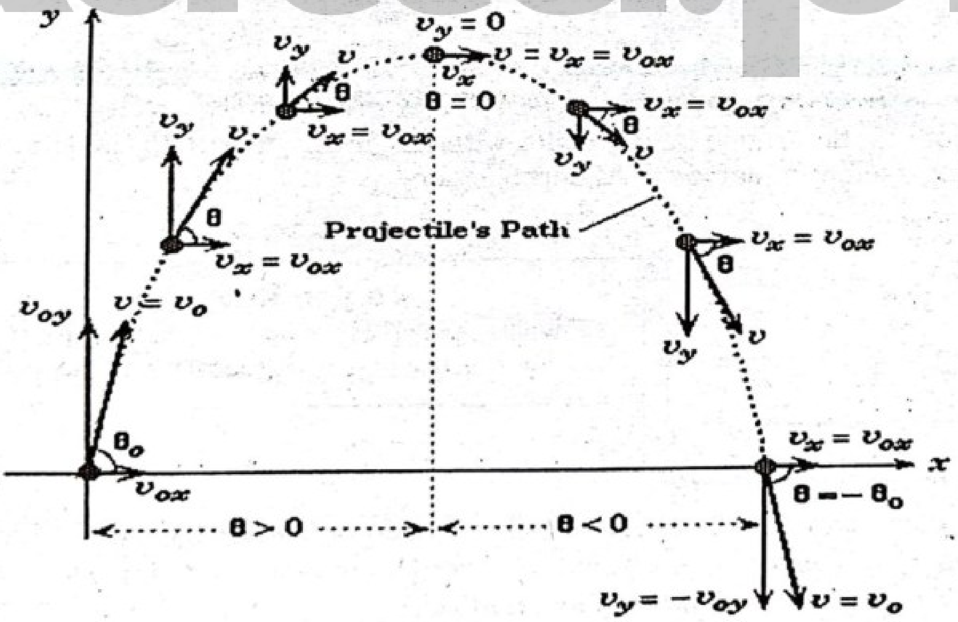
- Instantaneous velocity is maximum at point of projection and at the landing point and minimum at maximum height as $V_y=0$,at maximum height.
- Horizontal component of projectile velocity remains constant throughout the projectile motion.
- Vertical component decreases, becomes zero at maximum height and then increases till projectile hits the ground.

Note that: R = Range of projectile

$a_x = 0$

H = Maximum Height of projectile.

$a_y = -g$



- Horizontal and vertical coordinates of projectile at time 't' are given as;

$x = V_0 \cos\theta_0\, t$

$y = V_o \sin\theta_0\, t - \frac{1}{2} g t^2$

- *Trajectory of projectile is parabola in the absence of air friction. In the presence of air friction it is like parabola.*
- If two identical balls are thrown simultaneously from same height, one vertically and other horizontally, then both falls to the earth simultaneously.
- Time to reach maximum height is given as;

$$t = \frac{V_o \sin\theta_o}{g}$$

- Total time of flight is given as;

$$T = \frac{2V_o \sin\theta_o}{g}$$

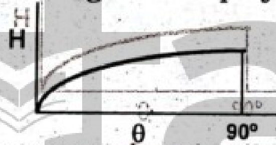
- Vertical range (height) is given as;

$$H = \frac{V_o^2 \sin^2\theta_o}{2g}$$

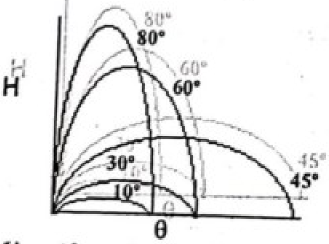
- Range (horizontal) is a distance between point of projection and point at which it comes back to its level of projection. It is given as;

$$R = \frac{V_o^2 \mathrm{Sin}2\theta_o}{g} = \frac{V_o^2 (2\sin\theta_o \cos\theta_o)}{g}$$

- Maximum horizontal range is at angle θ = **45°** and given as; $R_{max} = \frac{V_o^2}{g}$
- The relation between range and the height of the projectile is **$R\tan\theta = 4H$**
- Variation of maximum achievable height of the projectile with angle is drawn as below.



- With same initial velocity the range of projectile for two angles of projection will be equal if sum of the angles is equal to 90° i.e. $\theta_1 + \theta_2 = 90°$
- Variation in the range and height with angle of projection is shown with the following sketch for same speed of projection.



Do you know?

When angle of projection is 76° then range and maximum height of projectile are equal to each other.

Application to Ballistic Missile

- An **un-powered** and **un-guided** missile is called *ballistic missile*
- Friction of air effects the horizontal and vertical motion of the missile
- *Ballistic missiles are useful only for short ranges.*
- *Powered and remote control guided missiles are used for long ranges and* ***precision.***

PRACTICE EXERCISE

30 mins Time Yourself

(1) A particle moves along the x axis from x_i to x_f, which of the following values of the initial and final coordinates, which results in the displacement with the largest magnitude?

(a) $x_i = 4m, x_f = -2m$ (b) $x_i = -4m, xf = 4m$
(c) $x_i = 4m, x_f = 6m$ (d) $x_i = -4m, x_f = -8m$

(2) A car travels 40 kilometers at an average speed of 80km/h and then travels 40 kilometers at an average speed of 40km/h. The average speed of the car for this 80-km trip is

(a) 40km/h (b) 45km/h $2V_1V_2/V_1+V_2$
(c) 48km/h (d) 53km/h

(3) A man in a car moving with velocity of 36Km/hr. His speed with respect to the car is

(a) 10m/s (b) 36m/s
(c) zero (d) infinite

(4) When velocity time graph is a straight line parallel to time axis then

(a) acceleration is constant (b) acceleration is variable
(c) acceleration is zero (d) velocity is zero

(5) A baseball is thrown vertically into the air. The acceleration of the ball at its highest point is

(a) 2g, down (b) g, up
(c) zero (d) g, down

(6) A feather, initially at rest, is released in a vacuum 12 m above the surface of the earth. Which of the following statements is correct

(a) The maximum velocity of the feather is 9.8 m/s
(b) The acceleration of the feather remains constant during the fall
(c) The acceleration of the feather increases during the fall
(d) The acceleration of the feather decreases until terminal velocity is reached

(7) An object dropped from the window of a tall building hits the ground in 12.0 s. If its acceleration is $9.80\ m/s^2$, the height of the window above the ground is

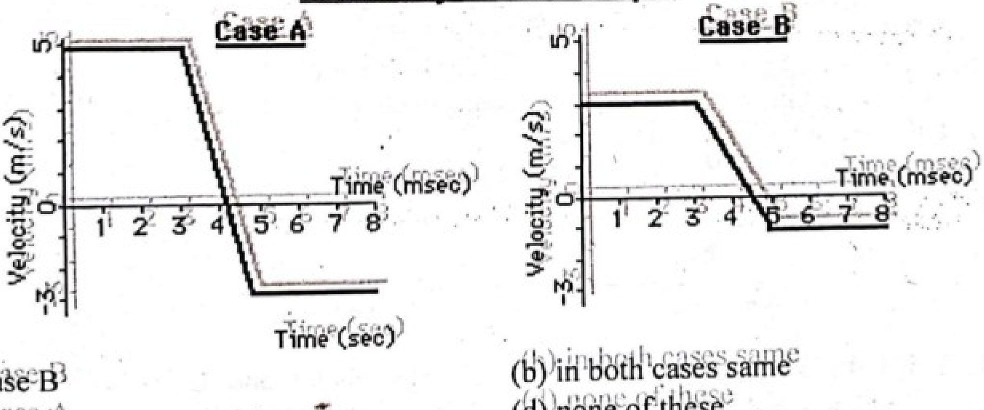
(a) 706 m (b) 353 m
(c) 118 m (d) 29.4m

(8) A baseball is hit straight up and is caught by the catcher 2.0 s later. The maximum height of the ball during this interval is:

(a) 4.9m (b) 19.6m
(c) 9.8m (d) 12.6m

(9) In the diagram given below in which case the acceleration is maximum

Velocity-Time Graph



(a) case B (b) in both cases same
(c) case A (d) none of these

(10) **Newton's laws do not hold good for particles, which**
(a) are at rest
(b)are moving slowly
(c) move with high velocity
(d) move with velocity comparable to velocity of light

(11) **1^{st} law of motion gives the definition of**
(a) rest (b) motion
(c) velocity (d) force

Imp
(12) **2^{nd} law of motion measures which quantity?**
(a) force (b) acceleration
(c) velocity (d) both force and acceleration

Imp
(13) **Imran travels 2m with speed v_1 and then 2m with speed v_2 his average speed is**
(a) $\frac{v_1+v_2}{2}$ (b) $\frac{v_1v_2}{2}$
(c) $\frac{v_1v_2}{v_1+v_2}$ (d) $\frac{2v_1v_2}{v_1+v_2}$

(14) **Momentum depends upon**
(a) force acts on the body (b) mass of the body
(c) velocity of the body (d) both mass and velocity of the body

(15) **Why does an object falling in the earth's gravitational field reach a steady velocity**
(a) air resistance increases with increase in velocity
Imp
(b) the earth's gravitational field decreases as the object falls
(c) the mass of the object remains constant
(d) the weight of the object increases as it falls

(16) **When a body moves in a straight line then its displacement coincides with**
Imp
(a) distance (b) force
(c) acceleration (d) both (a) and (b)

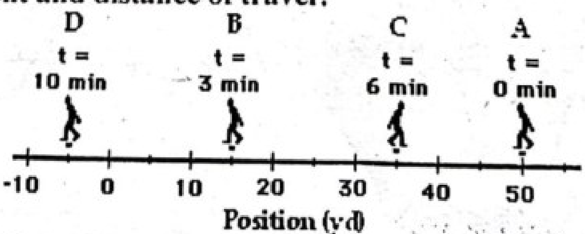
(17) **When two bodies stick together after collision, the collision is said to be**
(a) perfectly elastic (b) partially elastic
(c) completely inelastic (d) none of these

(18) **Motorcycle safety helmet extends the time of collision and hence decreasing the**
(a) chance of collision (b) force acting
(c) velocity (d) impulse

(19) **The collision between two bodies may be elastic if bodies are**
Imp
(a) solid and soft (b) soft and elastic
(c) solid and hard (d) hard and elastic

(20) **At maximum height on the trajectory which of projectile becomes zero**
(a) acceleration (b) velocity
(c) vertical velocity (d) horizontal velocity

(21) **In the given diagram, the coach moves from position A to B to C to D. What is the coach's resulting displacement and distance of travel?**



(a) 55yards left and 90 yards (b) 50yards left and 95 yards
(c) 55yards left and 95 yards (d) 45yards left and 95 yards

(22) A body is falling freely under gravity. How much distance it falls during an interval of time between 1st and 2nd seconds of its motion, taking g=10?

Imp

(a) 10 m (b) 15 m

(c) 20 m (d) 25 m

(23) A body, initially at rest, explodes into two masses M_1 and M_2 that move apart with speeds v_1 and v_2 respectively. What is the ratio $\frac{v_1}{v_2}$?

(a) $-\frac{M_2}{M_1}$ (b) $\frac{M_2}{M_1}$

(b) $\left(\frac{M_1}{M_2}\right)^{\frac{1}{2}}$ (d) $\left(\frac{M_2}{M_1}\right)^{\frac{1}{2}}$

(24) When collision between the bodies in a system is inelastic in nature then for the system

(a) momentum changes but K.E remain conserve

(b) K.E changes but momentum remain conserve

(c) both momentum and K.E changes

(d) both momentum and K.E remain conserve

(25) Which shows the correct relation between time of flight T and maximum height H?

(a) $H = \frac{gT^2}{8}$ (b) $H = \frac{8T^2}{g}$

(c) $H = \frac{8g}{T^2}$ (d) $H = \frac{8}{gT^2}$

(26) If an iron ball and wooden ball of the same radius are released from the height 'h' in vacuum, then time taken by both of them to reach the ground will be

(a) Unequal (b) Equal

(c) zero (d) none of these

(27) Taking off rocket can be explained by

(a) 1st law of motion (b) 2nd law of motion

(c) law of conservation of momentum (d) law of conservation of energy

(28) Which of the following is not an example of projectile motion.

(a) a gas filled balloon (b) bullet fired from gun

(c) a football kicked (d) a base ball shot

(29) What is the angle of projection for which the range and maximum height become equal?

(a) $\tan^{-1}\frac{1}{4}$ (b) $\tan^{-1} 4$

(c) $\cos^{-1}\frac{1}{4}$ (d) $\sin^{-1}\frac{1}{4}$

(30) **A projectile is launched at point O and follows the path OPQRS, as shown. Air resistance may be neglected.**

Imp

Which statement is true for the projectile when it is at the highest point Q of its path?

As V_x = const & $V_y = 0$ thus no change in acceleration so

(a) The horizontal component of the projectile's acceleration is zero.
(b) The horizontal component of the projectile's velocity is zero.
(c) The kinetic energy of the projectile is zero.
(d) The momentum of the projectile is zero.

(31) **When two bodies move toward each other with constant speeds the distance between them decreases at the rate of 6m/sec. If they move in the same direction the distance between them increases at the rate of 4m/sec. Then their speeds are**
(a) 5m/s, 1m/s
(b) 3m/s, 3m/s
(c) 6m/s, 1m/s
(d) 4m/s, 2m/s

(32) **Distance covered by a freely falling body in 2 seconds will be**
(a) 4.9m
(b) 19.6m
(c) 39.2m
(d) 44.1m

(33) **The distance covered by a body with uniform acceleration in time 't' starting from rest is**
(a) $at^2/2$
(b) Vt
(c) $a^2t/2$
(d) both a and b

(34) **Flight of a rocket in the space is an example of**

Imp

(a) second law of motion
(b) third law of motion
(c) first law of motion
(d) law of gravitation

(35) **The trajectory (or path) of a projectile flying against strong air currents is**

Imp

(a) straight line
(b) parabola
(c) hyperbola
(d) not a parabola

(36) **Rocket engine lifts rocket from the earth's surface, because hot gas with high velocity**

Imp

(a) react against the rocket and push it up
(b) push against the air
(c) push against the earth
(d) heat up the air which lifts the rocket

(37) **The force experienced by a wall on which water strikes normally at a speed of $10ms^{-1}$ and at a discharge of $0.0001m^3s^{-1}$ is.**

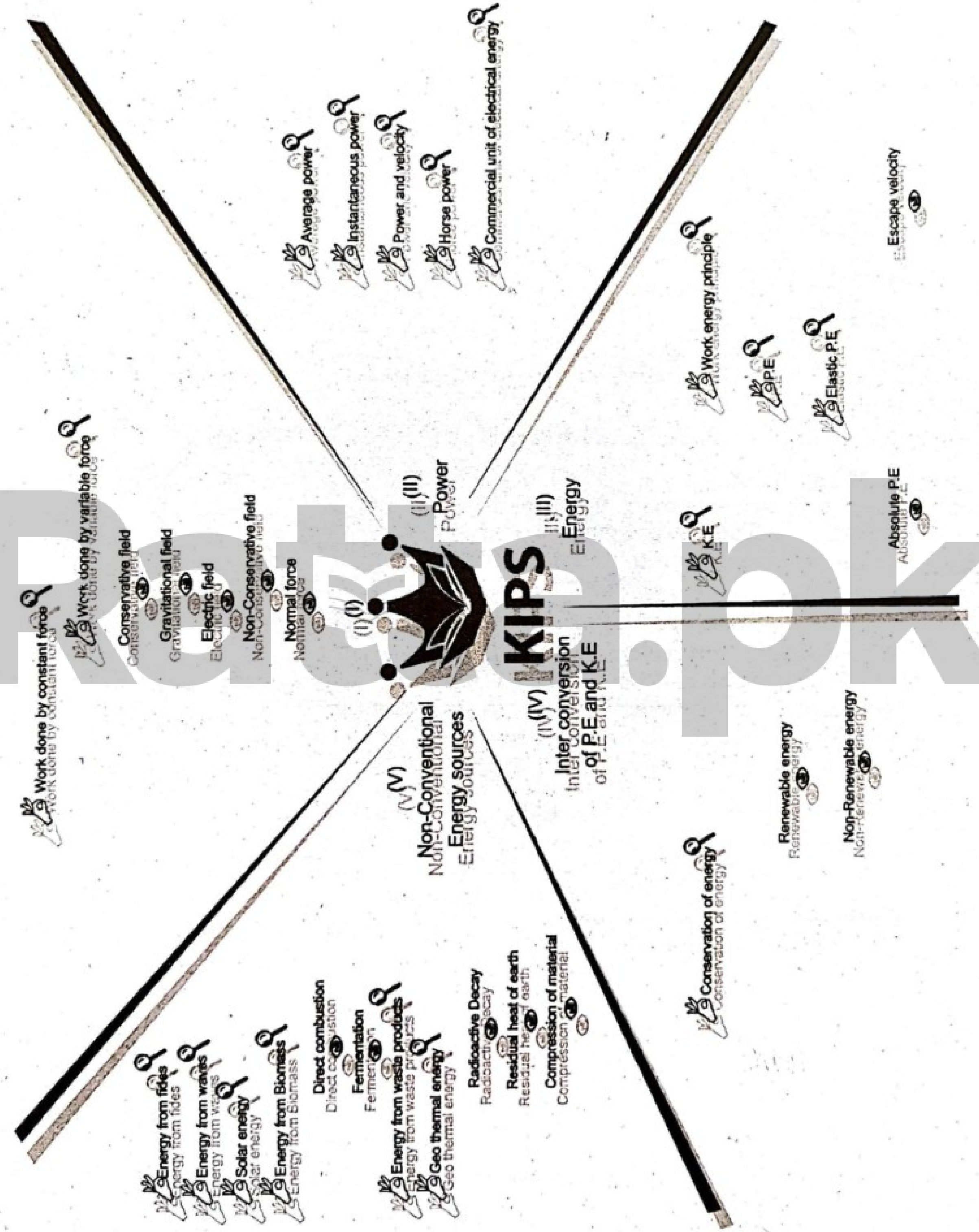
* Imp

(a) 1N
(b) 10N
(c) 100N
(d) none

(38) **Time rate of change of momentum is equal to**
(a) force
(b) impulse
(c) velocity
(d) both (a) and (c)

(39) **The range of the projectile at 30° is R_{30} and at 60° is R_{60} then**
(a) $R_{30} = R_{60}$
(b) $R_{30} = 2R_{60}$
(c) $2R_{30} = R_{60}$
(d) $R_{30} = R_{60}$ if initial velocities are same

(40) **Why Ballistic missiles fail in some circumstances of precision.**
(a) due to their shape
(b) due to air resistance
(c) due to angle of projection
(d) all of these


KIPS
(I)
Work done by constant force
Work done by variable force
Conservative field
Gravitational field
Electric field
Non-Conservative field
Normal force
(II) Power
Average power
Instantaneous power
Power and velocity
Horse power
Commercial unit of electrical energy
(III) Energy
Work energy principle
P.E
Elastic P.E
Escape velocity
K.E
Absolute P.E
(IV) Inter conversion of P.E and K.E
Conservation of energy
Renewable energy
Non-Renewable energy
(V) Non-Conventional Energy sources
Energy from tides
Energy from waves
Solar energy
Energy from Biomass
Direct combustion
Fermentation
Energy from waste products
Geo thermal energy
Radioactive Decay
Residual heat of earth
Compression of material

WORK

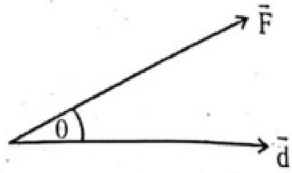
- The term 'work' has following meanings;

1. **Psychological Meaning:**
   All kinds of mental or physical activities are called work, but this kind of meanings is not used in physics.
2. **Scientific Meaning:**

(i) *If a force displaces or stops a moving body through a certain distance, the work is said to be done by the force on the body.*

(ii) *Dot product of force and displacement is called work.*

$$W = \vec{F}.\vec{d}$$
$$W = Fd\cos\theta$$
or $$W = (F\cos\theta)\,d \quad \text{or} \quad W = F\,(d\cos\theta)$$



- ***Positive Work***
  ⇒ For θ **< 90°,** work done is positive.
  ⇒ Maximum positive work is done if θ = **0°**
  Example when an engine pulls a train.
- ***Zero work***

⇒ Work will be zero

(i) when θ = **90°**,e.g.centripetal force and tension in pendulum string does not do any work

(ii) when F=0,

(iii) when $\vec{d} = 0$, e.g: car is not moving while its engine is running.

- ***Negative Work***

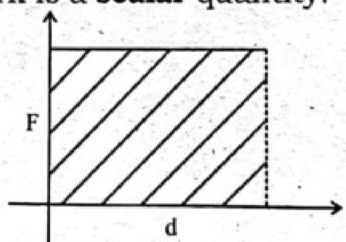
⇒ For θ **>90°,** work done is negative.

⇒ Maximum negative work when θ = **180°**

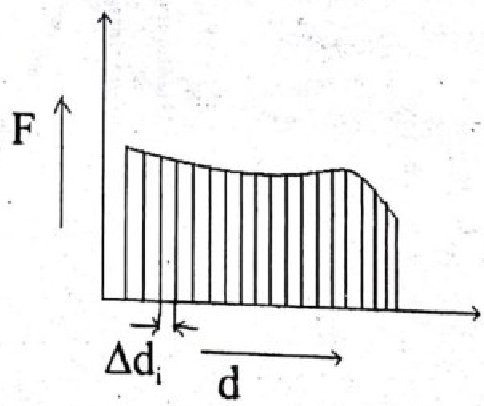
Example: work done by frictional forces

- *SI unit of work is joule (J).*
- *In particle physics, work is measured in electron volt (eV).*
- *Dimensionally work is equivalent to* ***[ML^2T^{-2}].***

Graphically work can be obtained from force displacement graph. The area under this graph is work done. Work is a **scalar** quantity.



(a) Work done by constant force
Area = Fd = work done.



(b) Work done by a variable force.

$$\text{Total Area} = \lim_{\Delta d \to 0} \sum_{i=1}^{n} F_i \cos\theta_i \Delta d_i = \text{work done}$$

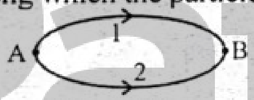
CONSERVATIVE FIELD

- If a field satisfies following two conditions, it is said to be conservative.

(i) Work done along a closed path is zero i.e. $W_{total} = 0$

(ii) Work done is independent of path followed by body but depends on final and initial position of a body.
Example: Electric field, Gravitational field.

- Frictional force is non-conservative force. Other non-conservative forces are propulsion force on rocket, force of a motor, tension in string etc.
- Spring force F = kx is conservative force.
- Conservative field and conservative force has the property of storing energy in the system. This energy is known as P.E of the system.

	CONSERVATIVE FORCES	NON-CONSERVATIVE FORCES
1.	The work done by these forces in carrying a particle around a closed path is zero i.e., $W_{total} = 0$.	The work done by these forces in carrying a particle around a closed path is not zero i.e., $W_{total} \neq 0$
2.	The work done by these forces in displacing a particle does not depend on the path along which the particle is displaced.  $W_{AB} = W_{BA}$	The work done by these forces depends upon the path along which the particle is displaced. In this case $(W_{AB}) \neq (W_{AB})$
3.	Under these forces the kinetic energy of the particle remains constant $K.E_i = K.E_f$ e.g., central forces, gravitational force elastic force, Lorentz force, electrostatic force, magnetic force etc.	Under these forces the kinetic energy of the particle changes $K.E_i \neq K.E_f$ e.g., frictional force, retarding force, viscous force, magnetic force due to an electric current etc. (all these are velocity dependent forces)

POWER

Time rate of doing work is called power.
Power = work/time

- *In linear motion*, power is given as;

$$P = \frac{W}{t} = \vec{F}.\vec{v}$$

- *In angular motion*, power is given as;

$$P = \vec{\tau}.\vec{\omega}$$

- *Average power* is given as;

$$\langle P \rangle = \frac{\langle W \rangle}{t} = F_{av}\frac{d}{t}$$

- *Instantaneous power* is given a

Do you know?
A person having more power than other person does not means that he has more energy as well. Reverse is also true.

Do you know?
If a spring is compressed then work done on it equals the increase in its elastic potential energy.

$$P = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t}$$

If $\langle P \rangle = P_{int}$, then body does work at constant rate.

- Unit of power is watt defined as;
  1 W = 1 J/1 sec
- *Dimensionally power is equivalent to* $[ML^2T^{-3}]$
- *I h.p = 746 watt = 550 foot pound/sec*
- *Commercial unit of electrical energy is kWh* **1kWh=3.6*10⁶ J**

Work energy Principle

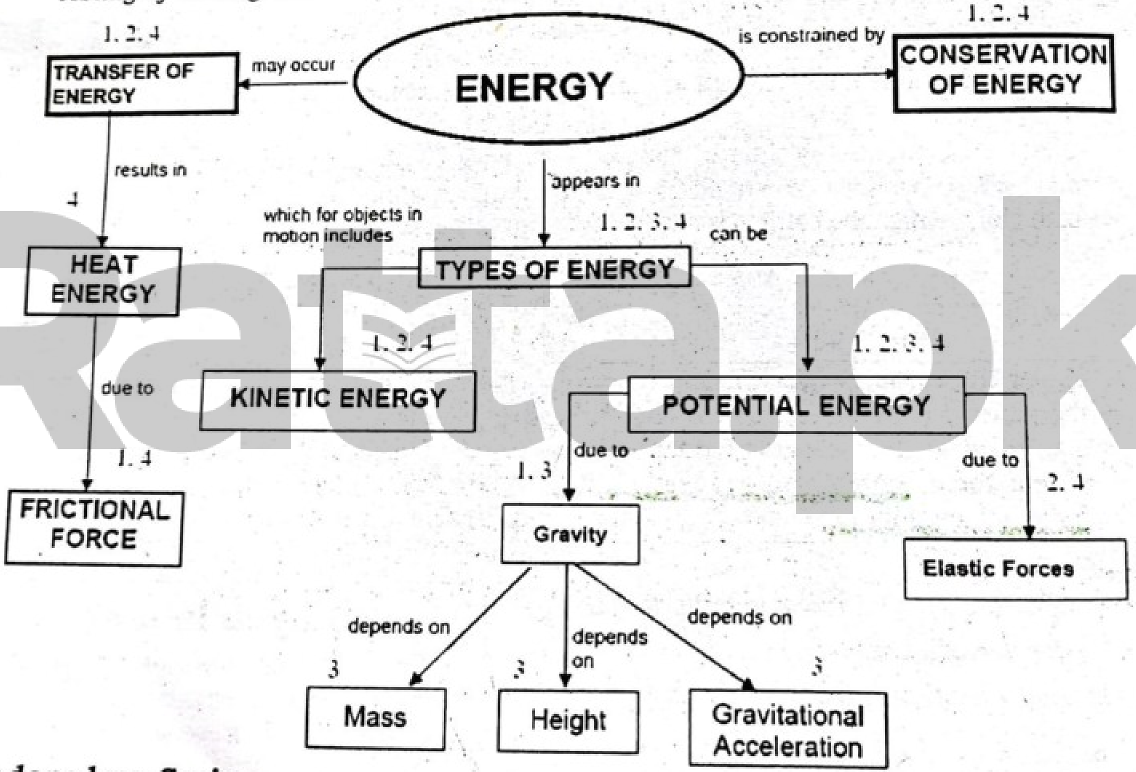
"Work done on the body equals change in its K.E"

i.e.

Work = $(K.E)_f - (K.E)_i$

ENERGY

Ability of a body to do work is called energy.



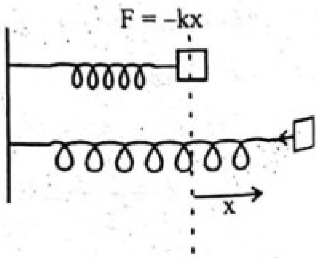
Work done by a Spring

While relaxing or returning back to its mean position the spring will do work:

$$W = \frac{1}{2}kx_o^2$$

If the block compresses the spring, spring force will do work

$$W = -\frac{1}{2}kx_o^2$$



EFFICIENCY

It is the ratio of required form of energy obtained from a system as output to the total energy given to it as input.

$$Efficiency = \frac{required\ form\ of\ output}{total\ input\ energy}$$

$$\text{Efficiency in percentage} = \frac{required\ form\ of\ output}{total\ input\ energy} \times 100 .$$

It has no unit.

IDEAL MACHINE

An ideal machine is a hypothetical machine whose output is equal to its input. For an ideal machine. Output = Input

Forms of energy

Name	Definition	Formula
K.E	Ability of a body to do work due to motion	$1/2\ mV^2 = p^2/2m$ P=momentum
Gravitational P.E	Ability of a body to do work due to position in gravitational field	$m\,g\,h$
Elastic P.E	Ability to do work due to elasticity	$\frac{1}{2}kx^2$
Electric P.E	Ability of a body to do work due to position in electric field	$q.\Delta V$

Applications of Gravitational P.E

- Absolute gravitational P.E of a body on surface of earth is given as

$$U_m = -\frac{GmM}{R}$$

- Negative sign due to selecting the zero reference level of potential energy at infinite distance from earth.
- Due to smaller value of g on Moon, a man can jump **higher** than on earth.
- Due to smaller value of g a man can't run faster on Moon.

Do you know?
The gravitational force holds inverse square relationship with the distance of the object from the center of earth.

Relation between momentum and K.E:

$$K.E = \frac{P^2}{2m}$$

ESCAPE VELOCITY

*The **minimum** initial velocity required by an object on earth to escape from earth's gravitational field.*

$$V_{esc} = \sqrt{\frac{2GM_e}{R_e}} = \sqrt{2g_eR_e}$$

<u>*Value of V_{esc}*</u> $=11.2\times10^3 ms^{-1} = 6.96 miles\ s^{-1} =$ **$11.2 kms^{-1}$**

$=25000$ miles $h^{-1} = 40320 kmh^{-1}$

Escape velocity is independent of the mass of the body.

INTER CONVERSION OF K.E AND P.E.

- *In absence of air friction we get*

  $$mgh = \frac{1}{2}mv^2$$

  $$v = \sqrt{2gh}$$

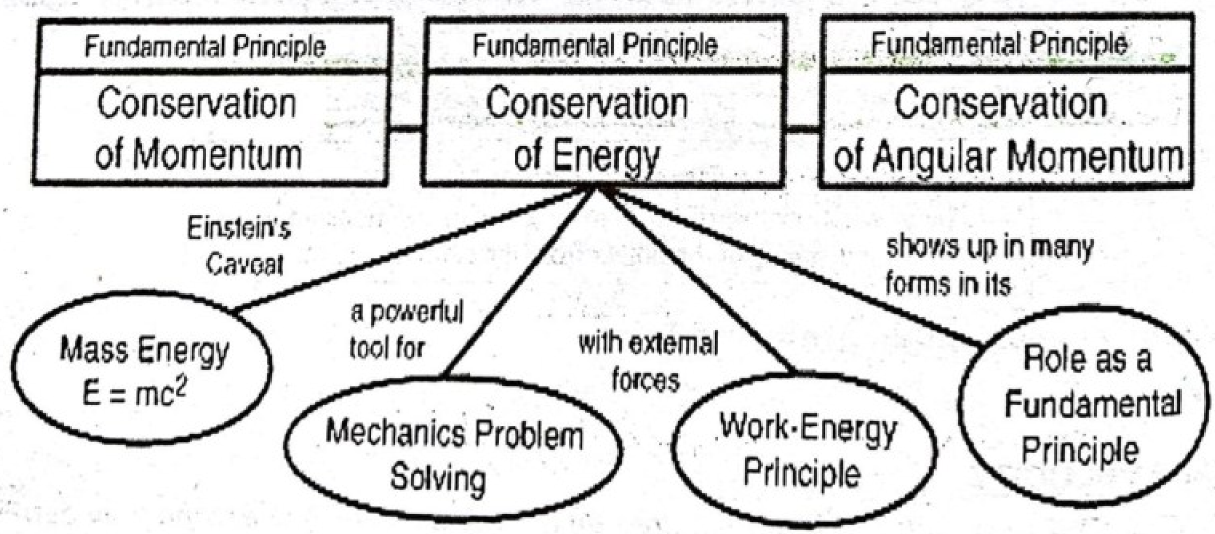
- If a body is dropped from height 'h' to earth's surface in presence of air, then; *Loss in P.E = gain in K.E + work done against air friction.*
- If a body is thrown vertically upward in gravitational field in the presence of air, then; *Loss in K.E = gain in P.E + work done against air friction.*

In the absence of air friction, increase in K.E = decrease in P.E. and vice – versa.

CONSERVATION OF ENERGY

Energy cannot be destroyed. It can be transformed from one form into another, but total amount of energy remain constant.

When a cup is dropped the P.E changes to K.E, but on striking the ground, the K.E changes to heat and sound but total at each instance is always **conserved.**



NON-CONVENTIONAL SOURCES OF ENERGY

- Non conventional source of energy
  - Energy from Tides
    - Water is allowed to fall in controlled manner from upstream to down stream
    - The energy of falling water derives the turbines
    - Turbines drive generators to produce electricity
  - Energy from Waves
    - Tidal movement and strong winds produces the waves on the water surface
    - They produce a relative movement in duck float and balance float.
    - This relative movement is used to run electricity generators.s
  - Solar Energy
    - Direct usage of solar energy
    - Indirect usage of solar energy
    - solar energy heats up a tank of water and produces stream, which is used to run stream turbines, and hence electricity is produced.
    - Photovoltaic cells convert solar energy to electrical energy.
  - Energy from Biomass
    - Biomass
    - Direct combustion
    - Converted in to fuel by Fermentation

Energy from Waste Products

Waste is burned in confined containers.

↓

Heat produced is used to generate steam

↓

Steam drives the turbines and produces electricity

Do you know?
The tides raise the water in the sea roughly twice a day.

- Normal incidence of solar energy outside the earth's atmosphere is about 1.4 kWm^{-2}.
- *Solar energy reaching on the surface of earth on a clear day at noon is about*
- *1 kWm^{-2}.*

Do you know?

How much energy per sq.m per second is absorbed by atmosphere?

- *Ethanol obtained from biomass is a replacement of gasoline.*
- *Methane obtained from biomass is a replacement of natural gas.*
- ***Sources of geothermal energy***

  (i) Radioactive decay (ii) Residual heat of the earth

  (iii) Compression of material in earth
- Annual consumption of energy is about 6×10^{13}kW
- Only 0.1% of solar energy is more than total energy required per annum on earth
- *Solar panel is series combination of solar cells.*
- Solar panels usually have ability to charge nickel-cadmium batteries in artificial satellites.

FOR YOUR INFORMATION

Source of energy	Original Source
Solar	Sun
Bio mass	Sun
Fossil fuels	Sun
Wind	Sun
Waves	Sun
Hydro electric	Sun
Tides	Moon
Geothermal	Earth

ENERGY SOURCES

Renewable	Nonrenewable
Hydroelectric	Coal
Wind	Natural gas
Tides	Oil
Geothermal*	Uranium
Biomass	Oil shale
Sunlight	Tar sands
Ethanol/Methanol**	

** Individual fields may run off*

*** Renewable when made from bio mass*

(1) **Work done will be maximum if the angle between the force F and displacement d is**
(a) 45° (b) 90°
(c) 180° (d) 0°

(2) **A field in which the work done in moving a body in a closed path is zero is called**
(a) electric field (b) conservative field
(c) electromagnetic field (d) gravitational field

(3) **When a force is perpendicular to the direction of motion of the body, then work done on the body is**
(a) zero (b) minimum
(c) infinity (d) maximum

(4) **Which of the following types of force does no work on the particle when it acts on it?**
(a) frictional force (b) gravitational force
(c) elastic force (d) centripetal force

(5) **If a body of mass of 2 kg is raised vertically through 2m, then the work done will be**
(a) 38.2 J (b) 392.1 J
(c) 39.2J (d) 3.92J

(6) **An elevator weighing $3.5 \times 10^{+6}$ N is raised to a height of 1000 m in the absence of friction, the work done is**
(a) 3.5×10^3 J (b) 3.5×10^4 J
(c) 3.5×10^6 J (d) 3.5×10^9 J

(7) **The average power and instantaneous power become equal if work is done at**
Imp
(a) any rate (b) variable rate
(c) uniform rate (d) high rate

(8) **The relation between horse power and watt is**
(a) 1 hp = 546 watts (b) 1 hp = 746 watts
(c) 1 hp = 1000 watts (d) 1 hp = 946 watts

(9) **Proton, electron, neutron and α particles have same momentum. Which of them have highest K.E?**
Imp
(a) proton (b) electron
(c) neutron (d) α-particle

(10) **The power output of a lamp is 6W. How much energy does the lamp give out in 2 minutes?**
(a) 3 J (b) 120J
(c) 720J (d) 430J

(11) **Work done by variable force is determine by dividing**
Imp
(a) force into small interval
(b) displacement into small interval
(c) both force and displacement into small intervals
(d) force into small and displacement into large intervals

(12) **Work done on the body equals**
(a) change in its K.E always (b) change in its P.E always
(c) change in its K.E or change in its P.E (d) neither change in K.E nor change in its P.E

(13) **The escape velocity of a body in gravitational field of earth is independent of**
(a) its mass
(b) the angle at which it is thrown
(c) both its mass and the angle at which it is thrown
(d) gravitational field of earth

(14) **The tides raise the water in the sea roughly in a day**
(a) once (b) twice
(c) four time (d) eight time

(15) **The source of geothermal energy is**
(a) decay of radioactive element in the earth (b) compression of material in the earth
(c) residual heat of the earth (d) all as said in a, b and c

(16) **The highest value of escape velocity in solar system is for planet**
(a) Earth (b) Neptune
(c) Jupiter (d) Moon

(17) **Work done by the force of friction is**
Imp (a) always positive (b) always negative
(c) positive only for small frictional force (d) positive only for large frictional force

(18) **Gravitational P.E of a body can be found by**
Imp (a) $\frac{Gm}{r}$ (b) mgh
(c) $-\frac{Gm}{r}$ (d) both "b" and "c"

(19) **If velocity is doubled, then**
(a) momentum increases to 4 times and K.E increases to 2 times
(b) momentum and K.E. remain same
(c) momentum increases to 2 times and K.E increases constant
(d) momentum increases to 2 times and K.E increases to 4 times

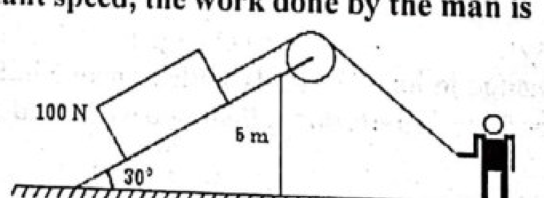
(20) **We get energy from food during a day which is equivalent to the energy obtained from __________ liter petrol.**
(a) 1 (b) $\frac{1}{2}$
Imp (c) $\frac{1}{3}$ (d) $\frac{1}{4}$

(21) **One mega watt hour is equal to**
(a) 3.6×10^{6} J (b) 3.6×10^{12} J
(c) 3.6×10^{8} J (d) 3.6×10^{9} J

(22) **A boy holds a 40-N weight at arm's length for 10s. His arm is 1.5m above the ground. The work done by the force of the boy on the weight while he is holding it is:**
(a) 0 As d=0 (b) 90J
(c) 60J (d) 40J

(23) **Work has the same dimension as that of**
(a) torque (b) angular momentum
(c) linear momentum (d) power

(24) **A man pulls a 100 N crate up a frictionless 30° slope 5m high, as shown. Assuming that the crate moves at constant speed, the work done by the man is**



(a) −500J (b) 500J
(c) −250J (d) 0

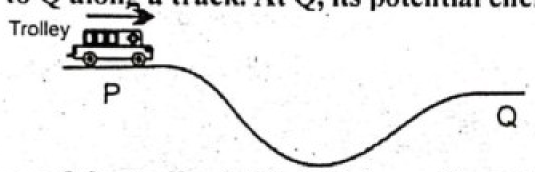
(25) **The relation between the escape velocity V_{esc} and orbital speed V_o is given by**
(a) $V_{esc} = 1/2 V_o$ (b) $V_{esc} = \sqrt{2}\, V_o$
(c) $V_{esc} = V_o$ (d) $V_{esc} = 2V_o$

(26) **The escape velocity form the earth surface in km s^{-1} is about**
(a) 4.2 km s^{-1} (b) 7.5 km s^{-1}
(c) 9.5 km s^{-1} (d) 11km s^{-1}

(27) **A boat moving at constant speed *v* through still water experiences a total frictional drag *F*. What is the power developed by the boat?**
(a) $\frac{1}{2}Fv$ (b) $\frac{1}{2}Fv^2$
(c) Fv^2 (d) Fv

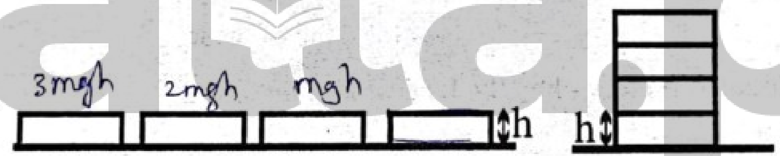
(28) **When two protons are brought close, their**
Imp
(a) Kinetic energy increases (b) P.E. increases
(c) P.E. decreases (d) P.E. doe not change

(29) **A trolley runs from P to Q along a track. At Q, its potential energy is 50 kJ less than at P.**



At P, the kinetic energy of the trolley is 5 kJ. Between P and Q the work that the trolley does against friction is 10 kJ. What is the kinetic energy of the trolley at Q?
(a) 35 kJ (b) 55 kJ
(c) 45 kJ (d) 65 kJ

(30) **Initially, four identical uniform blocks, each of mass *m* and thickness *h*, are spread on a table.**



Imp
How much work is done on the blocks in stacking them on top of one another?
(a) 2*mgh* (b) 4*mgh*
(c) 6mgh (d) 8mgh

(31) **Escape velocity depends upon the radius of Earth. Which one shows its proper dependence**
(a) $V \propto R$ (b) $V \propto R^{-\frac{1}{2}}$
(c) $V \propto R^{\frac{1}{2}}$ (d) $V \propto R^{-1}$

(32) **Temperature of hot igneous rocks is about**
(a) 20, 000^{0}C or more (b) 2000^{0}C or more
(c) 200^{0}C or more (d) 20^{0}C or more

(33) **A ball is thrown vertically upwards. Neglecting air resistance, which statement is correct?**
(a) The kinetic energy of the ball is greatest at the greatest height attained
(b). The potential energy of the ball increase uniformly with time during the ascent.
(c) By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion
(d) By the principle of conservation of energy, the total energy of the ball is constant throughout its motion

(34) Propulsion force of a rocket is

(a) non-conservative force

(b) conservative force

Imp

(c) conservative and rocket has reached high altitude

(d) none of these

(35) A car is driven along a level road. The total energy input from the petrol is 60kJ and the car wastes 45kJ of energy, what is the efficiency of car

(a) 25% (b) 15%

(c) 45% (d) 75%

(36) Geothermal energy is a ____________ source of energy.

(a) non-renewable (b) stable

(c) renewable (d) none of the above

(37) The source of tidal energy is

(a) sun (b) earth

(c) both (a) and (b) (d) moon

(38) ____________ cell converts solar energy into electrical energy

(a) rotatory (b) photovoltaic

(c) Galvanic (d) none of these

(39) Which of the following bodies has the largest kinetic energy?

(a) Mass 3M and speed v (b) Mass 3M and speed 2v

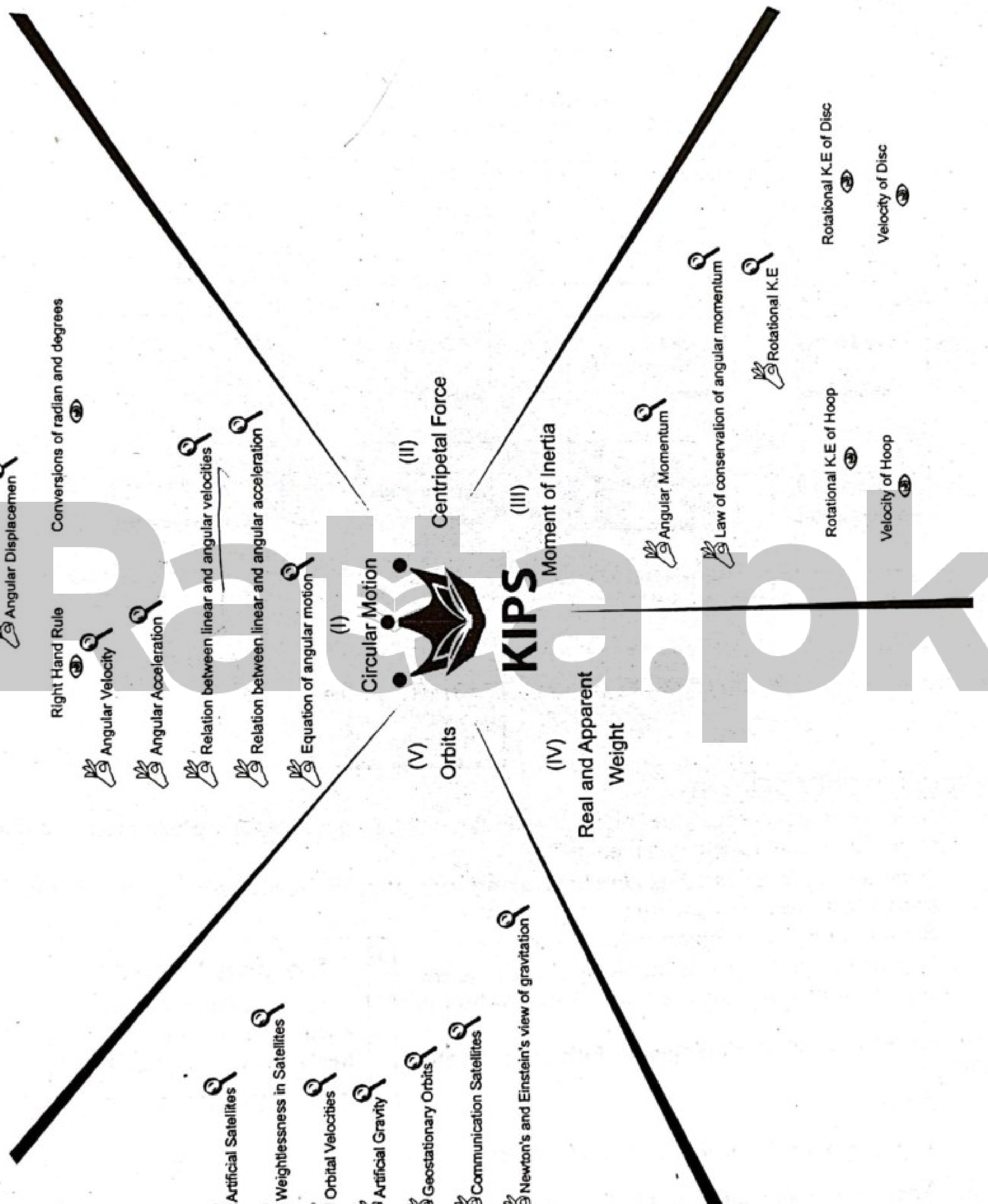
(c) Mass 2M and speed 3v $\frac{1}{2}mv^2$ $=18/8J$ (d) Mass M and speed 4v

(40) The amount of work required to stop a moving object is equal to:

Imp

(a) the velocity of the object (b) the mass of the object times its velocity

(c) the kinetic energy of the object (d) the mass of the object times its acceleration


KIPS
(I) Circular Motion
Angular Displacemen
Right Hand Rule
Conversions of radian and degrees
Angular Velocity
Angular Acceleration
Relation between linear and angular velocities
Relation between linear and angular acceleration
Equation of angular motion
(II) Centripetal Force
(III) Moment of Inertia
Angular Momentum
Law of conservation of angular momentum
Rotational K.E
Rotational K.E of Hoop
Velocity of Hoop
Rotational K.E of Disc
Velocity of Disc
(IV) Real and Apparent Weight
(V) Orbits
Artificial Satellites
Weightlessness in Satellites
Orbital Velocities
Artificial Gravity
Geostationary Orbits
Communication Satellites
Newton's and Einstein's view of gravitation

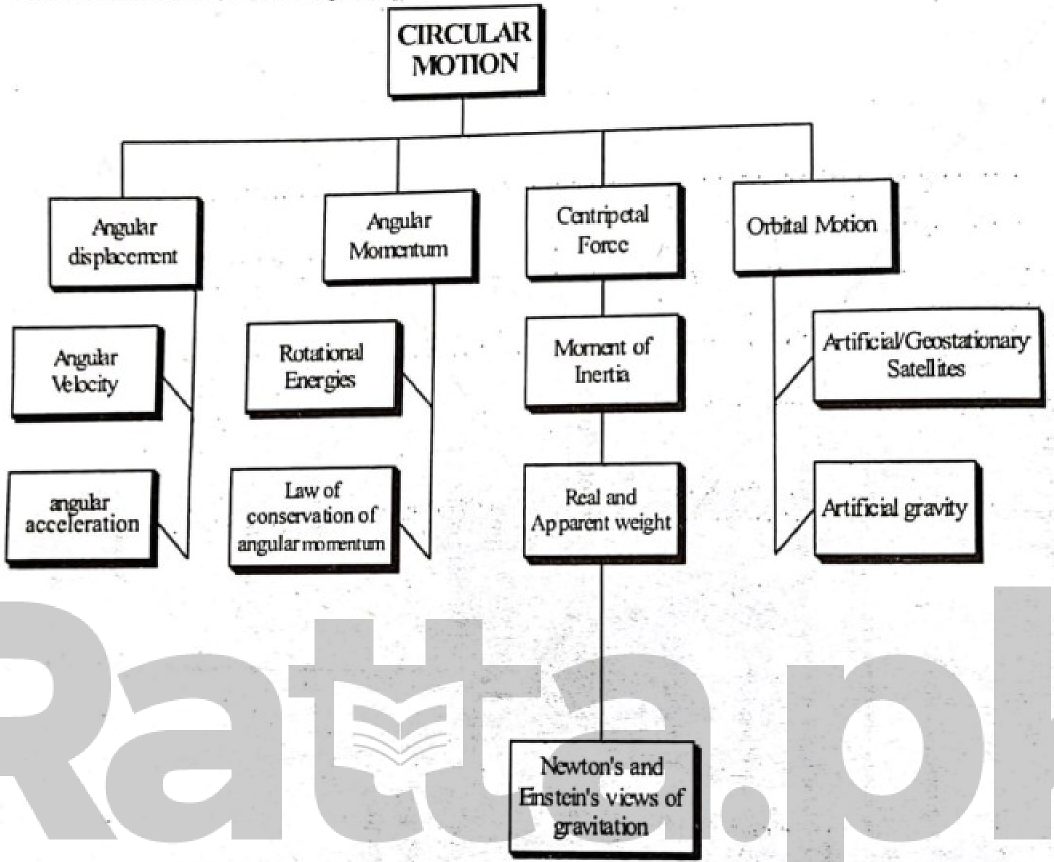
INTRODUCTION

Circular Motion

Motion of bodies in circular path is called circular motion

Angular Moti on

Circular motion of a body may also be called angular motion.



ANGULAR DISPLACEMENT

"It is the angle swept by the radial line during circular motion of a particle measured from some initial point to some final point."

- *Angular displacement has direction along axis of rotation and can be determined by right hand rule*
- *SI unit of angular displacement is radian*
- *One radian* is an angle made by an arc at the center, whose length is equal to the radius of circle.
- Definition of radian gives following useful relation:

$S = r\theta$

$1° = \frac{\pi}{180}$ rad = 0.0174 rad, 1 rad = 57.3°

Do you know?

For very small values of angular displacement it is treated as vector quantity.

- Angular displacement is angle in radian or degree covered by body having circular motion.
- Non S.I units are also used which are "degree" and "rev".

ANGULAR VELOCITY & ACCELERATION

- *Rate of change of angular displacement is called angular velocity;* , usually not a vector quantity.

  $\vec{\omega}_{ins} = \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t}$, always vector quantity.

- *Tangential and angular velocities are related as:*

  $v = \omega r$ *or* $\vec{v} = \vec{\omega} \times \vec{r}$

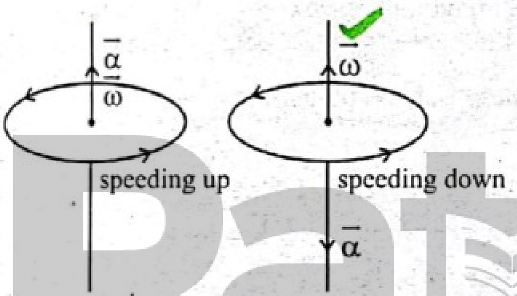
- *S.I unit of angular velocity is rads*$^{-1}$.
- *Rate of change of angular velocity is called angular acceleration.*

  $\vec{\alpha} = \frac{\Delta\vec{\omega}}{\Delta t}$

Do you know?

The angular velocity is practically measured in revolution per minute (rpm) as they provide an easy interpretation of angular motion.

- *SI unit of angular acceleration is rads*$^{-2}$
- Angular acceleration is a vector Quantity related to tangential acceleration $\vec{a}$ by the following formula $a = r\alpha$
- *Direction of angular acceleration and angular velocity is along axis of rotation.*



Do you know?

All the points on a rigid body rotating about a fixed axis have same angular displacement, velocity and acceleration.

- *If angular velocity increases, then $\vec{\omega}$ and α are in same direction and if angular velocity decreases, then $\vec{\omega}$ and $\vec{\alpha}$ are in opposite direction*

RIGID BODY

"A body, which maintains a constant distance between its two consecutive particles, when a definite load is applied to it."

*Note that all the solid bodies can be treated as rigid in **a specific range of loads** only.*

e.g. wall is treated to be rigid for a human being but not for hammer.

CENTRIPETAL FORCE & ACCELERATION

The force required to bend a straight line path of a body into the circular path is called centripetal force.

If the centripetal force is removed from the rotating object it will follow a straight-line motion confined on the tangent to that circular path.

ASSUMPTIONS

To derive the equations for the centripetal acceleration we **assume** that **speed of the object is constant so that the tangential component of velocity does not produce acceleration but radial component only.** The equation is

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}\hat{a}_t + \frac{v^2}{r}\hat{a}_r$$

- In vector form, centripetal force and acceleration can be written as;

$$\vec{F}_c = -mr\omega^2\hat{r} = -m\vec{r}\omega = -\left(\frac{mv^2}{r}\right)\hat{r} = -\left(\frac{mv^2}{r^2}\right)\vec{r}$$

$$\vec{a}_c = -r\omega^2\hat{r} = -\vec{r}\omega = -\left(\frac{v^2}{r}\right)\hat{r} = -\left(\frac{v^2}{r^2}\right)\vec{r}$$

- *Work done by centripetal force is zero.*
- Centripetal and centrifugal forces form true action & reaction pair but they can't balance each other because they don't act on same body.

COMPARISON OF LINEAR MOTION AND ANGULAR MOTION

ANALOGY BETWEEN TRANSLATORY MOTION AND ROTATORY MOTION	
✦ Linear displacement, $\vec{d}$	Angular displacement, $\vec{\theta}$
✦ Linear velocity, $\vec{v} = \frac{\Delta\vec{d}}{\Delta t}$	Angular velocity, $\vec{\omega} = \frac{\Delta\vec{\theta}}{\Delta t}$
✦ Acceleration or linear acceleration, $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$	Angular acceleration, $\vec{\alpha} = \frac{\Delta\vec{\omega}}{\Delta t}$
✦ Mass, m	Moment of inertia, $I = mr^2$
✦ Linear momentum, $\vec{P} = m\vec{v}$	Angular momentum, $\vec{L} = I\vec{\omega}$
✦ Impulse, $I \text{ or } J = \vec{F}\times\Delta t$	Angular impulse $= \vec{\tau}\times\Delta t$
✦ Force, $\vec{F} = m\vec{a} = \frac{\Delta\vec{p}}{\Delta t}$	Torque, $\vec{\tau} = I\vec{\alpha} = \frac{\Delta\vec{L}}{\Delta t}$
✦ Work, $W = \vec{F}.\vec{d} = \frac{1}{2}m\left(v_2^2 - v_1^2\right)$	Rotational work, $W_r = \tau\theta = \frac{1}{2}I\left(\omega_2^2 - \omega_1^2\right)$
✦ Kinetic energy, $K.E = \frac{1}{2}mV^2$	Kinetic energy of rotation, $K.E_r = \frac{1}{2}I\omega^2$
✦ **Newton's laws in linear motion:** **First law:** If F = 0 then v = constant **Second Law:** $\vec{F} = m\vec{a}$ **Third Law:** $\vec{F}_{12} = -\vec{F}_{21}$	**Newton's laws in rotational motion:** **First law:** If $\tau = 0$ then ω = constant **Second Law:** $\vec{\tau} = I\vec{\alpha}$ **Third Law:** $\vec{\tau}_{12} = -\vec{\tau}_{21}$
✦ **Equations of linear motion** **(i)** $v_f = v_i + at$ **(ii)** $S = v_it + \frac{1}{2}at^2$ **(iii)** $v_f^2 - v_i^2 = 2aS$	**Equations of rotational motion** **(i)** $\omega_f = \omega_i + \alpha t$ **(ii)** $\theta = \omega_i t + \frac{1}{2}\alpha t^2$ **(iii)** $\omega_f^2 - \omega_i^2 = 2\alpha\theta$
✦ Distance covered in nth second $S_n = v_i + \frac{a}{2}(2n-1)$	Angle subtended in nth second $\theta_n = \omega_i + \frac{\alpha}{2}(2n-1)$
✦ $S = vt$	$\theta = \omega t$
✦ $\langle v \rangle = \frac{v_i + v_f}{2}$	$\langle \omega \rangle = \frac{\omega_i + \omega_f}{2}$

MOMENT OF INERTIA

"The measure of hindrance offered by a rigid body against angular motion, when a disturbing torque acts over the body."

Mathematically expressed as moment of inertia =I = (m)(r^2).

It is measured in kgm^2. Moment of inertia depends upon

(i) *Mass of the body.*

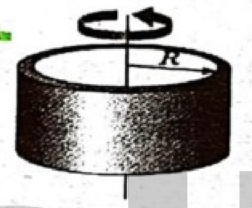
(ii) *Distribution of the mass about the axis of rotation.*

- *Moment of inertia plays same role in angular motion as the mass in linear motion.*

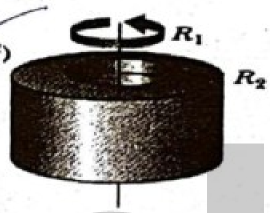
The equation $\tau = \mathbf{I}\,\alpha$ is the rotational analogue of the Newton's second law $\mathbf{F = ma}$

MOMENT OF INERTIA OF SOME REGULAR BODIES

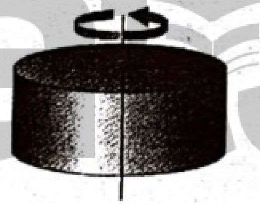
Hoop or cylindrical shell
$I_c = MR^2$



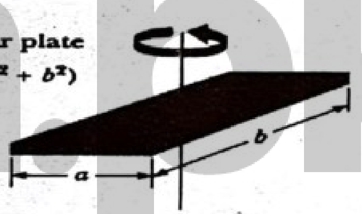
Hollow cylinder
$I_c = \frac{1}{2}M(R_1^2 + R_2^2)$



Solid cylinder or disk
$I_c = \frac{1}{2}MR^2$

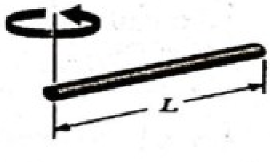


Rectangular plate
$I_c = \frac{1}{12}M(a^2 + b^2)$

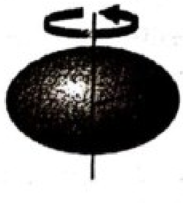


Long thin rod
$I_c = \frac{1}{12}ML^2$

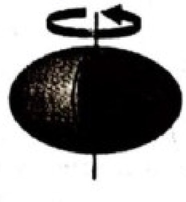
Long thin rod
$I = \frac{1}{3}ML^2$



Solid sphere
$I_c = \frac{2}{5}MR^2$



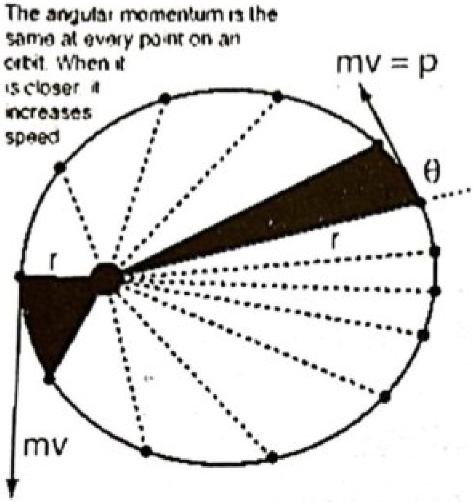
Thin spherical shell
$I_c = \frac{2}{3}MR^2$



ANGULAR MOMENTUM

- Angular momentum is due to spin motion or orbital motion of a body, and is also called moment of momentum.

ANGULAR MOMENTUM OF A PARTICLE



The angular momentum of a particle of mass m with respect to a chosen axis is given by

$$L = mvr \sin \theta$$

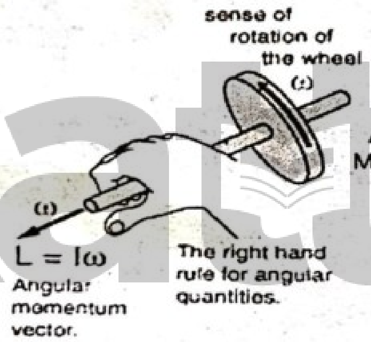
or more formally by the vector product

$$\vec{L} = \mathbf{r} \times \mathbf{p}$$

The direction is given by the right hand rule which would give L the direction out of the diagram. For a circular orbit, $\vec{L}$ becomes $L = mvr$

Angular Momentum

The angular momentum of a rigid object is defined as the product of the moment of inertia and the angular velocity.



Angular Momentum = Moment of Inertia × Angular Velocity

$$L = I \times \omega$$

- Orbital angular momentum is greater than spin angular momentum of an electron.

LAW OF CONSERVATION OF ANGULAR MOMENTUM

Angular momentum is a conserved quantity only in isolated system.

$L_1 = L_2$, $\sum \vec{L}$ *=constant if and only if* $\sum \tau_{ext} = 0$

OR $I_1 \omega_1 = I_2 \omega_2$

- Total angular momentum of a particle or a system of particle remains constant provided no net external torque acts on it.

Applications

- When a gymnast closes her arms while standing on a rotating joy wheel, the wheel speeds up, and slows down for the reverse just to conserve angular momentum.
- Springboard diver has more rotation when she pulls her body into closed tuck position.
- Balance of a sport bicycle is maintained due to the conservation of angular momentum for its thin rotating wheels.

ROTATIONAL K.E

- Rotational K.E is given by

$$K.E_{rot} = \frac{1}{2} I \omega^2$$

- Rotational K.E of disc

  $K.E_{rot} = \frac{1}{4}mv^2 = \frac{1}{2}(K.E_{lin})$
- Rotational K.E of hoop

  $K.E_{rot} = \frac{1}{2}mv^2 = (K.E_{lin})$
- Velocity of hoop at the bottom of an inclined plane

  $v = \sqrt{gh}$
- Velocity of disc at the bottom of an inclined plane

  $v = \sqrt{\frac{4}{3}gh} = \frac{2}{\sqrt{3}}\sqrt{gh}$

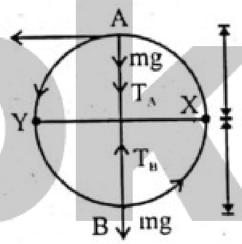
MOTION IN A VERTICAL CIRCLE

- When a body being tied to a string is whirled in a vertical plane, its speed is different at different points of the circular path.
- In such type of motion, the tension in the string and the centripetal force acting on the body go on varying continuously.
- At the highest point A, the tension in the string is T_A and the speed of the body is v_A then

  $T_A + mg = \frac{mv_A^2}{r}$ where r is the radius of circular path.
- If $T_A = 0$,

  then $mg = \frac{mv_A^2}{r}$

  or $v_A = \sqrt{gr}$



This speed of the body is known as critical speed and is denoted by v_c

$\therefore \quad v_c = \sqrt{gr}$

- In case $v_A < v_C$, the body will fall down.
- At the lowest point B, let v_B be the speed of the body and the tension in the string T_B,

so that $T_B - mg = \frac{mv_B^2}{r}$ or $T_B = mg + \frac{mv_B^2}{r}$

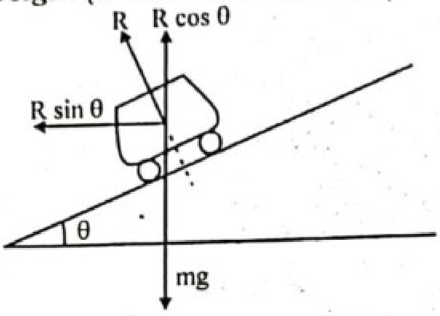
- Velocity at point B, $v_B = \sqrt{5gr}$

  Velocity at point X and Y = $v_X = v_Y = \sqrt{3gr}$

BANKING OF CURVED TRACKS

When a vehicle goes round a level curve the necessary centripetal force is provided by the force of friction between the tyres and the track (road or rail track). In case the frictional force, which acts as centripetal force and keeps the body moving along the circular path, is not enough to provide the necessary centripetal force, the vehicle will skid. To avoid the skidding of the vehicle the track is banked in such a way that the outer part of the track is raised a little above the inner side, which makes the track sloping towards the centre of the curve.

The inclination angle θ is chosen in such a way that the horizontal component of the normal reaction provides the centripetal force and the vertical component of the reaction supports the weight (as shown in figure)i.e.



$$R\sin\theta = mv^2/r \quad \ldots (9)$$

and
$$R\cos\theta = mg \quad \ldots (10)$$

From (9) and (10) we have

$$\tan\theta = \frac{v^2}{rg} \text{ or } \theta = \tan^{-1}\left(\frac{v^2}{rg}\right) \quad \ldots (11)$$

Under limiting condition i.e. for maximum speed for no skidding $\mu = \tan\theta$, hence.

$$V_{max} = \sqrt{\mu r g} \text{ or } V_{max} = \sqrt{\frac{r d g}{2 h}} \quad \ldots (12)$$

where h is the height of the centre of gravity and d is the separation between inner and outer wheels.

Quantity	Translation	Rotational	relation
Displacement	$\vec{d}$	θ	$s = r\theta$
velocity	$\vec{v} = \frac{\vec{d}}{t}$	$\omega = \frac{\Delta\theta}{\Delta t}$	$v = r\omega$
Acceleration	$a = \frac{\Delta v}{\Delta t}$	$\alpha = \frac{\Delta\omega}{\Delta t}$	$a_T = r\alpha$ $a_r = r\omega^2$
Mass/moment of Inertia	**m**	**I = mr²**	$I = \sum mr^2$
Force / Torque	**F = ma**	$\tau = r \times F$	
Kinetic Energy	**K.E** = $\frac{1}{2}mv^2$	**K.E$_{rot}$** = $\frac{1}{2}I\omega^2$	
Momentum	**p = mv**	**L = I**ω	$L = \vec{r} \times \vec{p}$
Power	**P = Fv**	**P** = $\tau\ \omega$	
Work	**W = F . d**	**W** = $\tau\ .\ \Delta\theta$	
Impulse	**I = Fx**Δt	**I** = $\tau\ \Delta t$	
Equilibrium	$\sum F = 0$	$\sum \tau = 0$	

ARTIFICIAL SATELLITES

An object revolving around a planet is called satellite

- Moon is natural satellite of Earth
- Moon's orbital angular velocity and spin angular velocity are same
- A man made rocket or space ship revolving around the earth is called *artificial satellite.*

- Artificial satellite revolves around the earth due to force of gravity.
- Critical velocity of an artificial satellite is $v=\sqrt{gR}$ **= 7.9 km s^{-1}**
- Period of such artificial satellite is 5060s or **84 min.**

Do you know?

Geostationary orbit is also called parking orbit.

Universal Gravitation: $F = G\dfrac{m_1m_2}{r^2}$

Acceleration due to gravity: $g = \dfrac{GM}{R^2}$

$g = \dfrac{G}{R^2}\left(\dfrac{4}{3}\pi R^3\rho\right)$ As mass (M) = volume $\left(\dfrac{4}{3}\pi R^3\right)\times$ density (ρ)

Hence $g = \dfrac{4}{3}\pi\rho GR$

VARIATIONS IN g

- **Variation in g above the surface of earth**

$g = \dfrac{GM}{R^2}$ ....(i) Or $g' = \dfrac{GM}{(R+h)^2}$ ....(ii)

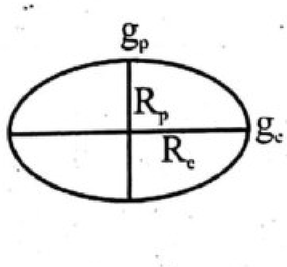
From equation (i) and (ii) $g' = g\left(\dfrac{R}{R+h}\right)^2 = g\dfrac{R^2}{r^2}$ [As $r = R+h$]

- As we go above the surface of the earth, the value of g decreases because $g' \propto \dfrac{1}{r^2}$
- If $r = \infty$ then $g' = 0$, i.e., at infinite distance from the earth, the value of g becomes zero.
- If $h << R$, i.e., height is negligible in comparison to the radius then $g' = g\left[1 - \dfrac{2h}{R}\right]$

So as we go above the surface of earth value of g decreases.

- **Variation in g with depth:** $g' = g\left[1 - \dfrac{d}{R}\right]$ $\because$ d = depth so as we go below the surface of earth the value of g decreases.
- **Variation in g Due to Shape of Earth:** Earth is elliptical in shape. It is flattened at the poles and bulged out at the equator. The R_e radius is about 21 km longer than polar radius at equator

As at equator $g_e = \dfrac{GM}{R_e^2}$ ....(i) **and** at poles $g_p = \dfrac{GM}{R_p^2}$ ....(ii)



- From (i) and (ii) $\dfrac{g_e}{g_p} = \dfrac{R_p^2}{R_e^2}$

Since $R_{equator} > R_{pole}$

and $g_{pole} > g_{equator}$

or $g_p = g_e + 0.018 ms^{-2}$

Therefore, the weight of body increases as it is taken from equator to the pole.

REAL AND APPARENT WEIGHT

Force with which earth attracts a body towards its center is equal to the real weight of the body.

The force required to prevent a body from free fall is called its apparent weight.

- Real weight can never be zero while apparent weight may be equal to real weight or zero or greater than real weight or less than real weight.
- To observe weightlessness, the frame of reference of observer must be the same as that of satellite or should move like parallel to its fall. e.g. weightlessness is observed only by observer inside the lift not outside it.
- Weight of object in a stationary or constantly moving lift is; $w' = mg$
- Weight of object in an elevator accelerating upward is; $w' = (g + a)m$

Weight of object in an elevator accelerating downward is; $w' = (g-a)\,m$

Do you know?

In a lift we only feel the difference in weights when the lift either start moving up or down, once constant velocity is achieved then weight variation become zero as well.

ORBITAL VELOCITY

Orbital velocity for a satellite is $v = \sqrt{\dfrac{MG}{r}}$

This shows that **mass** of satellite is not important in describing its orbit.

ARTIFICIAL GRAVITY

- *Artificial gravity is created by setting satellite into rotation about its own axis.*
- Artificial gravity is a reactional force, which gives impression of real gravity, when $\mathbf{a_c = g}$.
- Frequency of rotation to produce artificial gravity, in a spaceship is;

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$$

- Time period of rotation to produce artificial gravity, equal of real gravity is;

$$T = 2\pi\sqrt{\frac{R}{g}}$$

GEO-STATIONARY & COMMUNICATION SATELLITES

A satellite whose position does not change w.r.t a certain point on earth is called geo-stationary satellite.

- Its orbital motion is synchronized with the rotation of earth.
- *Geo-stationary satellite completes one rotation in* ***24 hours.***
- Three geo-stationary satellites placed at 120° intervals about the equator can effectively cover the whole globe for communication.
- Radius of geo-stationary orbit is given by

$$r=\left(\frac{GMT^2}{4\pi^2}\right)^{1/3}$$

Its value is 4.23×10^4 km from center of earth through the equator to the satellite.

- *Height of geo-stationary satellite above the equator is* ***36000km.***
- **Kepler's Third Law:** The square of the orbital period of a planet is proportional to the cube of the mean distance from the Sun i.e. $T^2 \propto r^3$.
- The largest satellite communication system is managed by 126 countries and named as International Telecommunication Satellite Organization ***(INTELSAT).***

NEWTON'S & EINSTEIN'S VIEWS OF GRAVITATION

- According to Newton, gravitational interaction is taking place between material objects and is directly proportional to the product of the masses of the objects and inversely proportional to the square of the distance between their centre.
- According to Einstein, gravitational interaction is taking place between material objects and also between material object and electromagnetic radiation.
- According to Einstein, gravity follows the inverse square law, but when gravitational fields are very strong inverse square law does not hold.
- *Einstein's theory is more close to the experimental facts than that of Newton's theory.*

Do you know?

If the gravity and acceleration of light are precisely equal then gravity must bend light as measured in solar eclipse in 1919.

PRACTICE EXERCISE

30 mins Time Yourself

(1) **The rotational K.E of hoop is**

(a) equal to its translational K.E
(b) half than its translational K.E
(c) double than its translational K.E
(d) four times than its translational K.E

(2) **A hoop and disc have same mass and radius. Their rotational K.E are related by an equation**

(a) $K.E_{hoop} = K.E_{disc}$
(b) $K.E_{hoop} = 2K.E_{disc}$
(c) $K.E_{hoop} = 1/2K.E_{disc}$
(d) $K.E_{hoop} = 4K.E_{disc}$

(3) **The angular velocity of the minute hand of a clock is**

(a) $\frac{2\pi}{60} rads^{-1}$
(b) $\frac{\pi}{24} rads^{-1}$
(c) $\frac{2\pi}{3600} rads^{-1}$
(d) $\frac{\pi}{3600} rads^{-1}$

$a_c = \frac{v^2}{r}$

(4) **If a wheel turns with constant angular speed then:**

(a) each point on its rim moves with constant velocity
(b) each point on its rim moves with constant acceleration
(c) the angle through which the wheel turns in each second decreases as time goes on
Imp (d) the wheel turns through equal angles in equal times

(5) **A boy suddenly comes and sit on the circular rotating table. What will remain conserved**

(a) angular momentum
(b) linear velocity
Imp (c) kinetic energy
(d) none of these

(6) **According to Einstein, the gravity interaction is possible between**

(a) material objects only
(b) both material objects and electromagnetic radiation
(c) electromagnetic radiations only
(d) none of the above

(7) **Ten seconds after an electric fan is turned on, the fan rotates at 300rev/min. Its average angular acceleration is**

(a) 30 rad/s^2
(b) 3.14rad/s^2
(c) 30 rev/s^2
(d) 500 rev/s^2

(8) **The period of a circular motion is given by**

(a) $T = rV$
(b) $T = \omega w$
(c) $T = 2\pi\omega$
(d) $T = 2\pi/\omega$

(9) **The direction of linear velocity of body moving in a circle is**

(a) along the axis of rotation
(b) along the tangent
(c) directed towards the center
(d) directed away form the center

(10) **When a body moves in a circle, the angle between its linear velocity and angular velocity is always**

(a) 180°
(b) 0°
(c) 90°
(d) 45°

(11) An arc of length equal to the circumference of circle subtends an angle

(a) π radian (b) 2π radian

(c) $\pi/2$ radian (d) 4π radian

(12) The relation between linear and angular acceleration is

(a) $\vec{\alpha}=\vec{a}\times\vec{r}$ v (b) $\vec{a}=\vec{r}\times\vec{\alpha}$

(c) $\vec{a}=\vec{\alpha}\times\vec{r}$ (d) $\vec{r}=\vec{\alpha}\times\vec{a}$

(13) When a body is whirled in a horizontal circle by means of a string the centripetal force is supplied by

Imp

(a) mass of a body (b) velocity of body

(c) tension in the string (d) centripetal acceleration

(14) What remains constant when the earth revolve around the sun

(a) Linear momentum (b) Linear K.E

(c) Angular K.E (d) Angular momentum

(15) The angular momentum of a body is conserved if

(a) Force acting on it constant (b) Force acting on it is zero

(c) Torque acting on it is zero (d) All of these

(16) A stone is whirled in a vertical circle at the end of a string. When the stone is at the highest position the tension in the string is

Imp

(a) maximum (b) zero

(c) equal to the weight of the stone (d) less than the weight of the stone

(17) The angular speed of hour's hand of mechanical watch is -------- radian per hours

(a) $\pi/6$ $\theta = \frac{2\pi}{12} = \frac{\pi}{6}$ rad/hr (b) $\pi/4$

(c) $\pi/12$ (d) $\pi/8$

(18) $\tau = I\alpha$ for an object rotating about a fixed axis, where τ is the net torque acting on it, I is its rotational inertia, and α is its angular acceleration. This expression:

Imp

(a) follows directly from Newton's second law

(b is the definition of angular acceleration

(c) is the definition of rotational inertia

(d) is the definition of torque

(19) If a car moves with a uniform speed of 2 ms^{-1} in a circle of radius 0.4m. Its angular speed is

(a) 4 rad. s^{-1} (b) 5 rad. s^{-1}

(c) 1.6 rad. s^{-1} (d) 2.8 ms^{-1}

(20) A body can have constant velocity when it follows a

Imp

(a) elliptical path (b) circular path → direction ch

(c) parabolic path (d) rectilinear path

(21) A body moving along the circumference of a circle, completes two revolutions. If the radius of the circular path is R, total angular displacement covered is

(a) π R (b) 2πR

(c) zero (d) 4π

(22) A hoop rolls with constant velocity and without sliding along level ground. Its rotational kinetic energy is:
(a) half its translational kinetic energy (b) twice its translational kinetic energy
(c) four times its translational kinetic energy (d) the same as its translational kinetic energy

(23) Time taken by geostationary satellite to complete one rotation around earth is
(a) 1 year (b) 1 day
(c) 1 hour (d) 84 min

(24) The direction of angular momentum is along
(a) Tangent to the circle (b) Inward the radius
(c) Axis of rotation (d) Outward of the radius

(25) If a wheel of radius r turns through an angle of 30°, then the distance through which any point on its rim moves is
(a) $\frac{\pi}{3}r$ (b) $\frac{\pi}{6}r$
(c) $\frac{\pi}{30}r$ (d) $\frac{\pi}{180}r$

(26) In angular motion, Newton's second law of motion is
(a) F=ma (b) $F=\Delta p/\Delta t$
(c) $\tau = I\alpha$ (d) all of above

(27) Angular speed of second's hand of a watch in $rads^{-1}$ is
(a) π (b) $\frac{\pi}{2}$
(c) $\frac{\pi}{30}$ (d) $\frac{\pi}{180}$

(28) The angle subtended by an arc equal to radius is
(a) 1 rad (b) One degree
(c) 1 Revolution (d) All

(29) What is outward force acting on a mass of 10kg when rotating at one end of an inelastic string 10m long at speed of 1m/s?
(a) 1N (b) 10N
(c) 2N (d) 100N

(30) If we whirl a stone at the end of a string in the vertical circle, it is likely to break when the stone is
Imp
(a) at the highest point $v = \sqrt{gR}$ (b) at the lowest point $V = \sqrt{5gR}$ → to tangent.
(c) at any point during motion (d) at the point where gravity is not acting

(31) Global positioning system consists of how many satellites?
(a) 24 Natural satellites (b) 24 artificial satellites
(c) 3 synchronous satellites (d) both "b" and "c"

(32) A man of weight W is standing on an elevator which is ascending with an acceleration a. The apparent weight of the man is
(a) mg (b) ma – mg
(c) mg + ma (d) mg – ma

(33) A body moving in a circular path of radius r has tangential acceleration a_t, and centripetal acceleration a_c. If the body is moving at constant speed v, what are the magnitudes of a_t and a_c?

Imp

	Tangential acceleration, a_t	Centripetal acceleration, a_c
(a)	rv^2	0
(b)	v^2/r	0
(c)	0 moving	v^2/r
(d)	0	v^2r

(34) An object of mass of 2 kg rotates at constant speed in a horizontal circle of radius 5 m. The time for one complete revolution is 3 s. What is the magnitude of the resultant force acting on the object?

(a) $\frac{4\pi^2}{9}N$
(b) $\frac{40\pi^2}{9}N$
(c) $\frac{100\pi^2}{9}N$
(d) $\frac{400\pi^2}{9}N$

$V = r\omega$
$V = r\frac{2\pi}{T}$
$V = \frac{5\times 2\pi}{3} = \frac{10\pi}{3}$
$F = \frac{mv^2}{r} = \frac{2\times 100\pi^2}{9\times 5}$
$F = 40\pi^2/9$

(35) A satellite moving round the earth constitutes
(a) An inertial frame of reference
(b) non inertial frame
(c) neither inertial nor non inertial
(d) both inertial and non inertial

(36) A body of mass 10kg is rotating in a circular path of radius 'r' m with constant speed. The work done in one complete revolution is
(a) 10.3 $rads^{-1}$
(b) zero
(c) 100 $rads^{-1}$
(d) 0.5 $rads^{-1}$

(37) A monkey sits on the pan of a spring scale kept in an elevator. The reading of the spring scale will be maximum when the elevator
(a) Is stationary
(b) Accelerates downwards
(c) Cable brakes and it falls freely towards the earth
(d) Accelerates upwards

(38) A satellite moves at constant speed in a circular orbit about the Earth. Which statement about the momentum and kinetic energy of the satellite is correct?

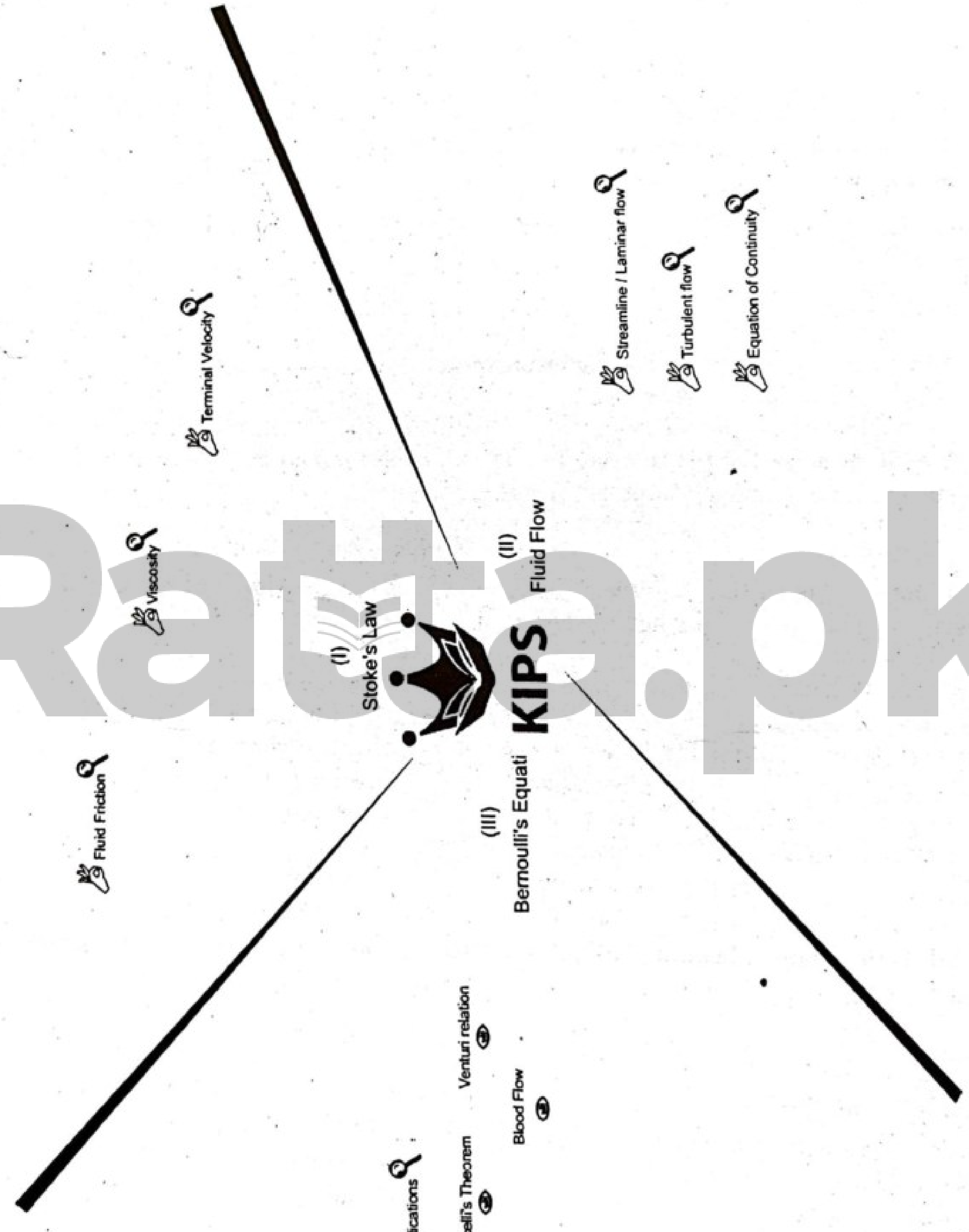
Imp

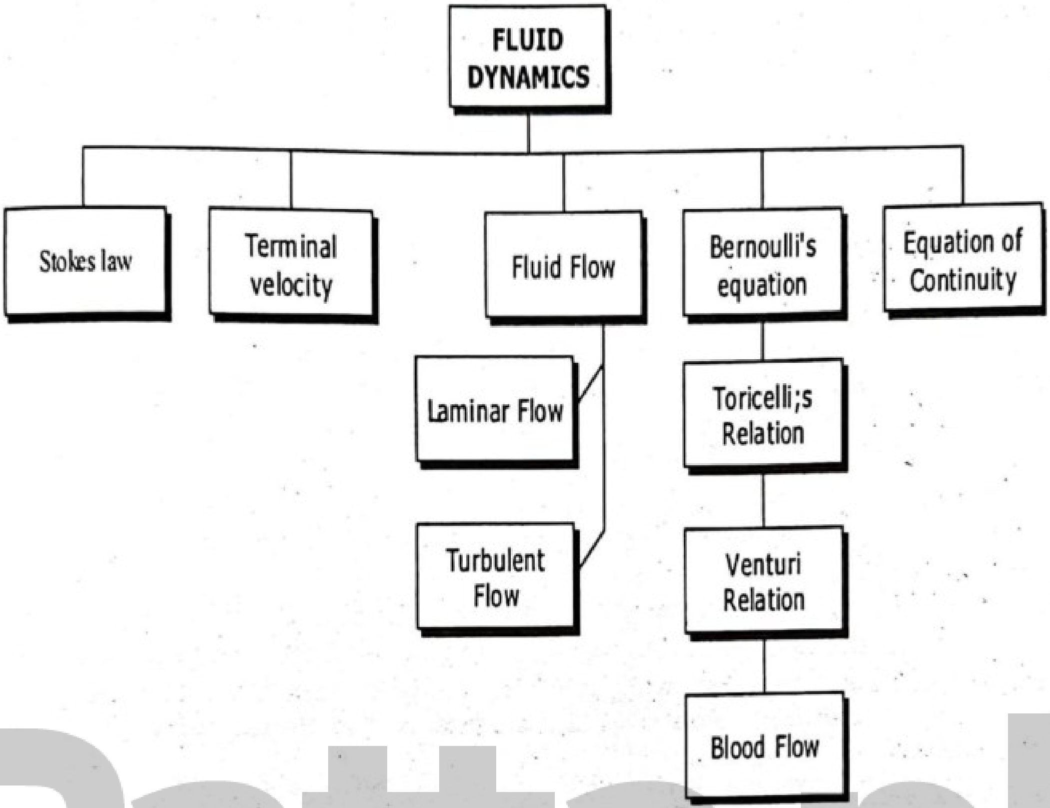
	Momentum	Kinetic energy
(a)	constant	Changing
(b)	changing	Constant
(c)	Changing	Changing
(d)	constant	Constant

(39) If θ_E is the angle of bending of light predicted by Einstein's theory of gravity and θ_N that by Newton's, then

(a) $\theta_E = \theta_N$
(b) $\theta_E = \frac{1}{2}\theta_N$
(c) $\theta_E = 2\theta_N$
(d) no relation exists between θ_E and θ_N

(40) In the solar eclipse of 1919 A.D., bending of starlight was measured to be
(a) 1.745 degree
(b) 1.745 minute
(c) 1.745 seconds
(d) 1.745 radian


(I)
Stoke's Law
(II)
Fluid Flow
(III)
Bernoulli's Equati
KIPS
Fluid Friction
Viscosity
Terminal Velocity
Streamline / Laminar flow
Turbulent flow
Equation of Continuity
Applications
Toricelli's Theorem
Blood Flow
Venturi relation



FLUIDS

- Liquids and gases can flow and are thereby classified as fluids.
- The study of fluids at rest is called hydrostatics.
- Fluid dynamics deals with fluids in motion.

DENSITY

- The density of a substance is defined as its mass per unit volume.

$$\text{Density}(\rho)=\frac{\text{Mass}(M)}{\text{Volume}(V)}$$

- In M.K. S. System the unit of density is kg m^{-3}.

PRESSURE

- Pressure at a point due to fluid is the normal force exerted by the fluid on unit area containing the point. $\text{Pressure}(P)=\frac{\text{Force}(F)}{\text{Area}(A)}$
- Pressure is a scalar quantity. Pressure acts normal to a surface and it is always compressive in nature, therefore, only its magnitude is required for its complete description.
- The S.I unit of pressure is Nm^{-2} and is also called Pascal (Pa).
- The other common units of pressure are the atmospheric and bar.

  1 atm = 1.013×10^5 Pa ⇒ 1 bar = 10^5 Pa

Thrust: The normal force exerted by a fluid on any surface in contact with it is called thrust.

Thrust = Pressure x Area

Pascal's law: The pressure exerted by a liquid at a point is the same in all directions. This principle is used in a hydraulic jack or a lift where a heavy load can be lifted up by a small force.

$$\frac{F_1}{F_2} = \frac{A_1}{A_2}$$

Archimedes principle: A body that is partially or entirely submerged in a fluid, feels an upward force equal in magnitude to the weight of the displaced fluid.

Buoyancy: (i) The upward thrust which any liquid or gas exerts upon a body partly or fully submerged in it, is called its buoyancy. **(ii)** The point at which the buoyancy of a liquid acts on a body is called the centre of buoyancy or the centre of floatation. The magnitude of this upward buoyant force (B) is given by Archimedes principle. i.e. $\mathbf{B = V \rho g}$

Laws of floatation:

- When $w > w'$, i.e., the weight of the body is greater than the weight of the liquid displaced by it, the body sinks.
- When $w = w'$, i.e. when the weight of the body is equal to the weight of the liquid displaced by it, the body floats being wholly immersed anywhere in the liquid.
- **When $w < w'$, i.e., then the weight of the body is less than the weight of liquid displaced by it, the body floats on the surface of the liquid being partly immersed in the liquid.**

VISCOUS DRAG AND STOKES LAW

- Viscosity is the measure of the force required to slide one layer of a liquid over another.
- *SI unit of coefficient of viscosity is $Kgm^{-1}s^{-1}$ and dimension $ML^{-1}T^{-1}$*
- Substance that flows easily like water etc has lesser coefficient of viscosity.
- The force experienced by an object while moving in a viscous medium is called drag force.
- The drag force in a medium depends on the profile of the object and velocity of the same object and nature of medium

  Mathematically drag force can be related with above stated factors using Stoke's law

$$F_D = 6\pi \eta r v.$$

The Stoke's law holds well at low speeds only for spherical bodies.

TERMINAL VELOCITY

When a spherical object falling gains a constant speed in a medium then the net force acting on it is zero and the corresponding speed is called as terminal velocity represented as v_t

$$v_t = \left(\frac{g}{6\pi\eta r}\right)m \text{ and } v_t = \left(\frac{2\rho g}{9\eta}\right)r^2$$

Where η is the coefficient of viscosity of the fluid.

> **Do you know?**
> When an object is moving in a fluid at considerably higher speed then the force of drag is no more proportional to the speed.

FLUID FLOW

- In a fluid if every particle that passes a particular point, moves along exactly the same path as followed by particles which passed that point earlier then flow is called *streamline or laminar*
- Irregular or unsteady flow of the fluid is called *turbulent flow*

Characteristics of ideal fluid

(i) It is non viscous i.e. $\eta = 0$

(ii) It is incompressible $\rho = \text{constt}$

(iii) Its motion is steady

Do you know?

At higher velocities of fluid flow the flow is turbulent and in this condition the exact path of fluid

EQUATION OF CONTINUITY

This equation is obtained by using law of conservation of mass of flowing of ideal fluid, and is written as:

- $\rho_1 A_1 v_1 = \rho_2 A_2 v_2$ OR $\rho A v$ = constant $= \frac{\text{mass}}{\text{time}}$ = mass flow rate of fluid.
- $A_1 v_1 = A_2 v_2$ OR Av = constant = $\frac{\text{volume}}{\text{time}}$ = volume flow rate of fluid.

The flow of ideal fluid is assumed to be streamline flow.

BERNOULLI'S EQUATION

Bernoulli's equation is derived from conservation of mechanical energy.

- *Bernoulli's equation is* $P + \frac{1}{2}\rho v^2 + \rho g h = \textit{constant}$
- Fluid have three types of energies-

(i) Potential energy = mgh or potential energy per unit volume = $\rho g h$

(ii) Kinetic energy = $\frac{1}{2}mv^2$ or kinetic energy per unit volume = $\frac{1}{2}\rho v^2$

(iii) Pressure energy = PV or pressure energy per unit volume = P

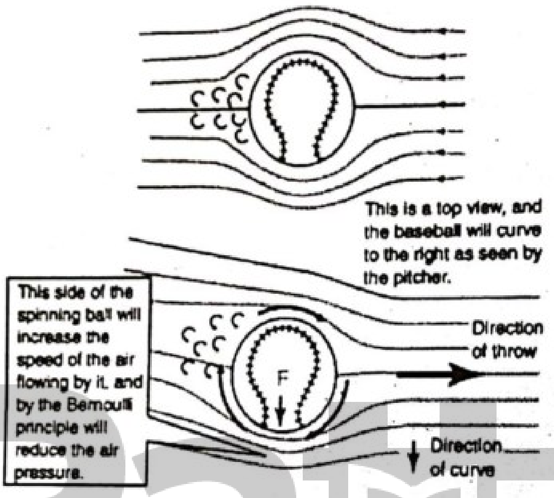
APPLICATIONS

Speed of Efflux

- Speed of efflux is determined by Torricelli's theorem $v = \sqrt{2g(h_1 - h_2)}$ where $(h_1 - h_2)$ is height of fluid level from the orifice. This theorem explains streamline flow of ideal fluid under the action of gravity only.
- Speed of efflux depends upon the height through which fluid falls under the action of gravity
- Pressure of fluid increases if the speed of fluid decreases and vice versa, according to the relation $P + \frac{1}{2}\rho v^2 = \text{constant}$.
- An aero plane lifts due to the difference of pressure of air on its wings
- Swing in cricket and tennis ball is also due to difference of pressure on its two sides
- There is a danger that a person standing near a fast moving train to fall towards it.
- Venturimeter is a device used to measure the speed of liquid flow
- Venturimeter works according to venturi relation which is $\mathbf{P_1 - P_2 = \frac{1}{2}\rho v_2^2}$
- Mixing of petrol with air in carburetor is according to the Bernoulli's principle.

Do you know?

The cricket players usually polish one side of the ball and make rough other side of the ball to get the differential air pressure to swing a ball in air.



The roughness of the ball's surface and the laces on the ball are important! With a perfectly smooth ball you would not get enough interaction with the air.

BLOOD PRESSURE

- Instrument used to measure blood pressure is called sphygmomanometer. It measures blood pressure dynamically.
- Blood pressure is measured in the unit of torr, 1 torr = 133.3 Nm^{-2}=1mm of Hg
- For normal healthy person the systolic pressure is 120 torr and diastolic pressure is 75 to 80 torr.
- At systolic pressure the blood flow is turbulent while it switches from turbulent to laminar at diastolic pressure.

PRACTICE EXERCISE

30 mins Time Yourself

(1) **Which of the given has the least coefficient of viscosity**

(a) milk (b) water
(c) tarcoal (d) engine oil

(2) **The rain drop falling from the sky reach the ground with**

(a) constant acceleration (b) terminal velocity
(c) constant pressure (d) variable acceleration

(3) **Terminal velocity is**

Imp
(a) uniform (b) maximum
(c) uniform and maximum (d) neither uniform nor maximum

(4) **When body moves with terminal velocity the acceleration in the body become**

(a) zero (b) maximum
(c) variable (d) infinite

(5) **Terminal velocity is given by equation**

(a) $v_t = gr^2\rho/\eta$ (b) $v_t = 2gr^2\rho/9\eta$
(c) $v_t = gr^2\rho/9\eta$ (d) $v_t = 9gr^2\rho/2\eta$

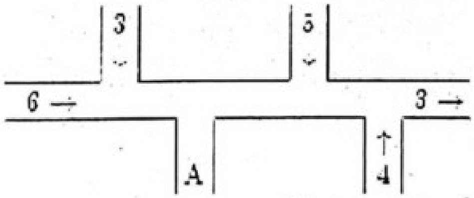
(6) **A fluid is undergoing steady flow. Therefore:**

(a) the density does not vary from point to point
Imp
(b) the velocity of any given molecule of fluid does not change
(c) he flow is not uphill or downhill
(d) the velocity at any given point does not vary with time

(7) **The flow of ideal fluid is**

(a) turbulent (b) along random path
(c) along straight path (d) streamline

(8) **The diagram shows a pipe of uniform cross section in which water is flowing. The directions of flow and the volume flow rates (in cm^3s^{-1}) are shown for various portions of the pipe. The direction of flow and the volume flow rate in the portion marked A are:**



(a) ↓ and $3cm^3/s$ (b) ↑ and $7cm^3/s$
(c) ↑ and $11cm^3/s$ (d) ↓ and $15cm^3/s$

(9) **When fluid is incompressible then**

Imp
(a) velocity of the fluid is constant (b) flow of the fluid is along straight line
(c) density of the fluid is constant (d) volume of the fluid is constant

(10) **An ideal fluid flows through horizontal tube of variable diameter. The pressure is lowest where the**

(a) velocity is highest (b) diameter is smallest
(c) diameter is largest (d) both a and b

(11) **According to equation of continuity $A_1v_1 = A_2v_2$ = constant, the constant is equal to**
(a) flow rate (b) volume of fluid
(c) mass of fluid (d) density of fluid

(12) **Equation of continuity is obtained by applying law of conservation of**
Imp (a) mass (b) energy
(c) momentum (d) all

(13) **Bernoulli's equation is applicable to**
(a) flow of liquids (b) viscosity
(c) surface tension (d) all of these

(14) **Speed of efflux can be determined by applying**
(a) Bernoulli's theorem (b) Torricelli`s theorem
(c) venture relation (d) stoke's law

(15) **A constriction in a pipe reduces its diameter from 4.0cm to 2 .0cm. Where the pipe is narrow the water speed is 8.0m/s. Where it is wide the water speed is:**
(a) 16m/s (b) 32m/s
(c) 4.0m/s (d) 2.0m/s

(16) **If a stream of air is blown under one of the pans of a physical balance in equilibrium, then pan may**
(a) go up (b) not effected
(c) go down (d) none of these

(17) **A man standing near a fast moving train may fall**
(a) over the train (b) away from the train
(c) towards the train (d) on himself

(18) **For which position, maximum blood pressure in the body have the smallest value?**
(a) standing straight (b) sitting on chair
(c) sitting on ground (d) lying horizontally

(19) **Two fog droplets have radii 2:3, their terminal velocities are**
(a) 4:6 (b) 4:9
(c) 2:9 (d) 4:3

(20) **Bernoulli's equation is obtained by applying law of conservation of**
Imp (a) mass (b) energy
(c) momentum (d) fluid

(21) **Venturi meter is used to measure**
(a) fluid pressure (b) fluid density
(c) fluid speed (d) fluid energy

(22) **A large water tank, open at the top, has a small hole in the bottom. When the water level is 30m above the bottom of the tank, the speed of the water leaking from the hole**
(a) is 24m/s
(b) is 2.5m/s
(c) is 44m/s
(d) cannot be calculated unless the areas of the hole and tank are given

(23) **Stoke's law is applicable if body has_________ shape**
imp
(a) rough (b) square
(c) spherical (d) all of these

(24) **The velocity of the flow of liquid through an orifice at the bottom of a tank depends upon**
(a) density of liquid (b) height of liquid above the orifice
(c) gravity (d) both b and c

(25) **Systolic pressure is called**
(a) lower blood pressure (b) higher blood pressure
(c) normal blood pressure (d) abnormal blood pressure

(26) **Instrument used to measure blood pressure is called**
(a) venturimeter (b) blood pressure
(c) sphygmomanometer (d) sonometer

(27) **A chimney works best if air exposed to the chimney is**
(a) stationary (b) moving
(c) moving slowly (d) moving fast

(28) **Which one is venturi relation?**
(a) $P_1\text{-}P_2 = \frac{1}{2}\rho v_2{}^2$ (b) $P_1 - P_2 = \frac{1}{2}\rho v_1^2$
(c) $P + \frac{1}{2}\rho v^2 = \text{constant}$ (d) both "a" and "b"

(29) **The effect of the decrease in pressure with the increase of the speed of fluid in a horizontal pipe is known as**
(a) Bernoulli`s effect (b) Torricelli`s effect
(c) Venturi effect (d) Stoke's effect

(30) **Ideal fluid is**
(a) non-viscous (b) incompressible
(c) steady flow (d) possess all properties

(31) **Laminar flow usually occurs at speeds which are**
imp
(a) low (b) high
(c) very high (d) some time high and some time low

(32) **For ________ flow the path of the fluid particles cannot be tracked.**
(a) laminar (b) streamline
(c) turbulent (d) both (a) and (b)

(33) **Sphygmomanometers measure blood pressure.**
(a) statically (b) dynamically
(c) some time static and some time dynamic (d) none of these

(34) **Carburetor of a car is an application of**
(a) Venturi meter (b) Bernoulli's equation
(c) Equation of continuity (d) Torricelli's theorem

(35) **The blood flow is ______________ flow at systolic pressure**
(a) laminar (b) turbulent
(c) mixed (d) none

(36) **A person blows across the top of one arm of a U-tube partially filled with water. The water in that arm:**
(a) drops slightly
(b) rises slightly
(c) rises if the blowing is soft but drops if it is hard
(d) remains at the same height

(37) **Bernoulli's equation is applicable for**

(a) laminar flow (b) turbulent flow

(c) static fluids (d) all kinds of flow

(38) **The density of human blood is nearly equal to**

(a) water (b) honey

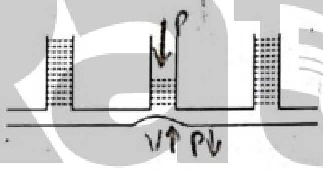
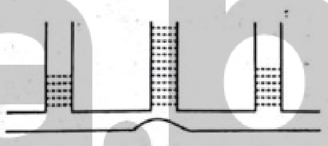
(c) mercury (d) oil (kerosene)

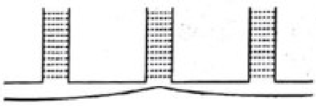
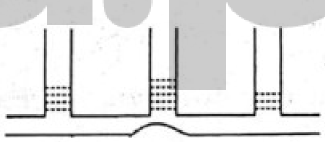
(39) **The speed of the fluid is maximum in the venture-meter at**

(a) convergent duct (b) divergent duct

(c) at end points (d) at any point

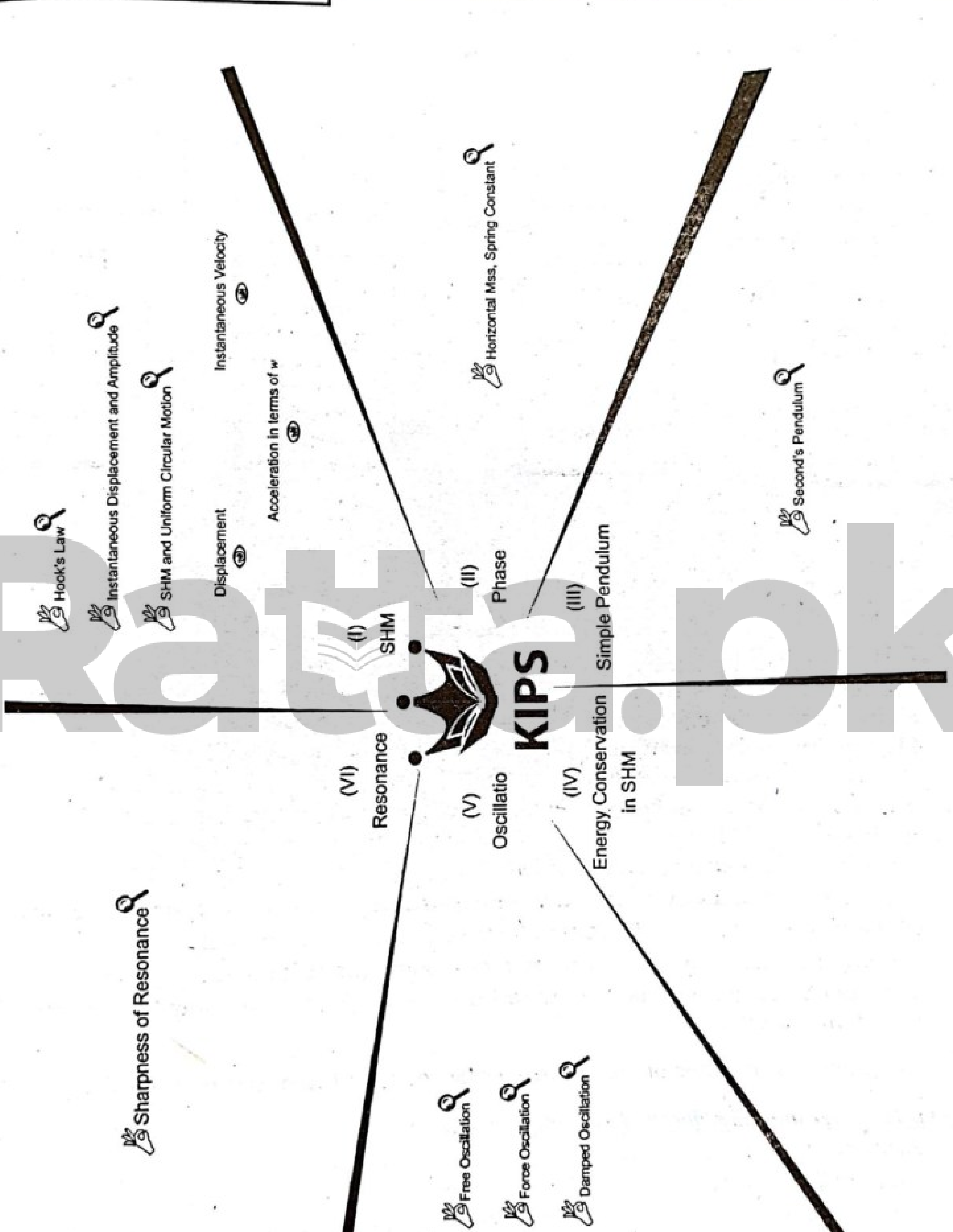
(40) **Which figure shows correct representation of water level in capillaries attached with pipe in which water is flowing**

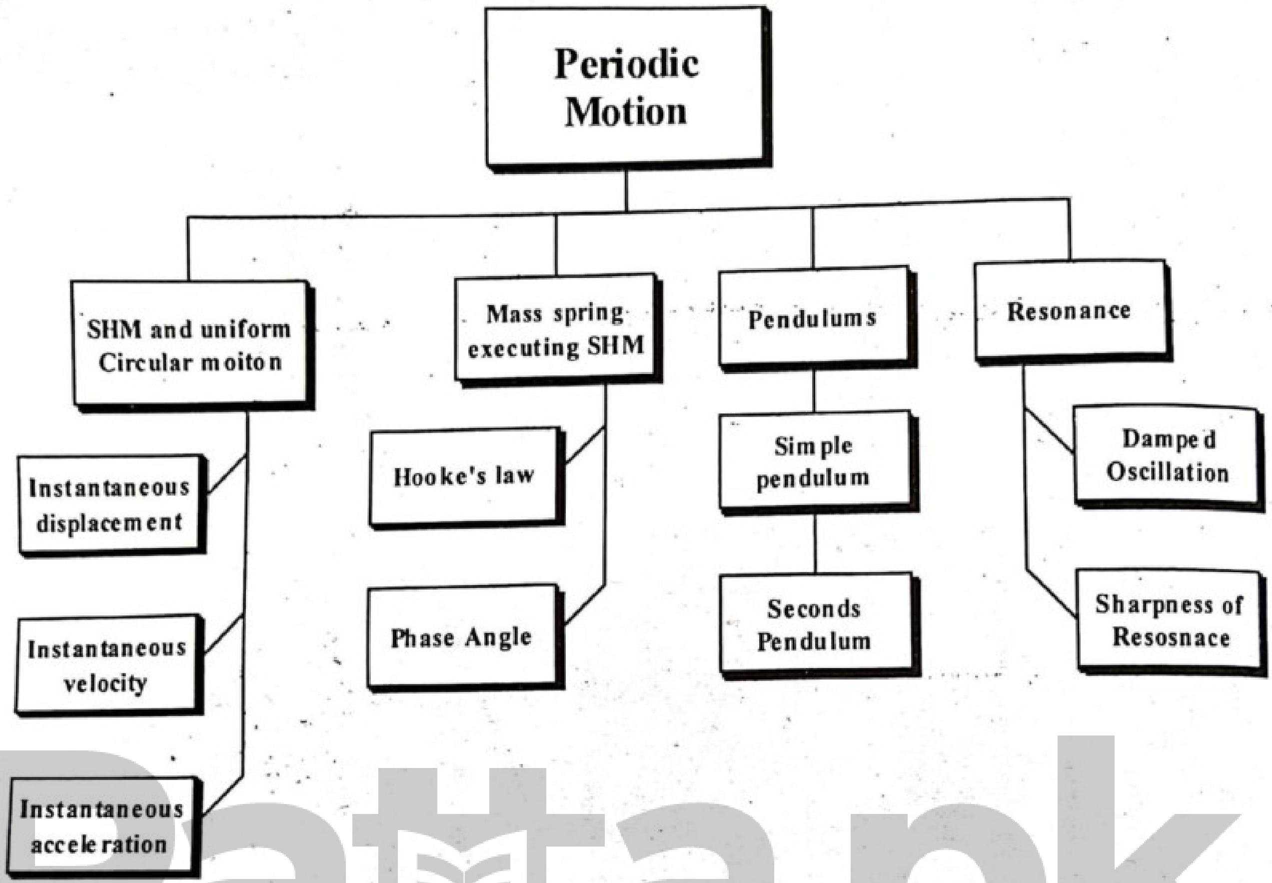
(a)  (b) 

(c)  (d) 

Chapter 7

OSCILLATIONS





SIMPLE HARMONIC MOTION

- *Vibratory motion* is that in which a body moves to and fro about a fixed position along same path. e.g.

(i) Motion of simple pendulum
(ii) Motion of molecules of a solid

- *Simple harmonic motion(SHM) is a special type of vibratory motion in which;*

(i) $a \propto -x$
(ii) *a is directed towards mean position.*

- *Restoring force is* always directed towards mean position hence assigned negative sign.
- *Periodic motion* is that which repeats itself after equal time intervals.
- *Vibration* is one complete round trip of a body about its mean position.
- *Time period* is defined as time taken by vibrating body to complete its one vibration and denoted by T.
- *Frequency* is number of vibrations per second and denoted by f so $f = \frac{1}{T}$

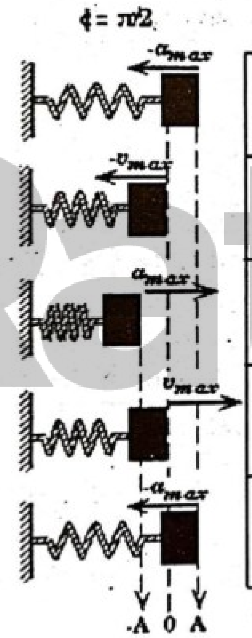
Its unit is Hz, other units are vibrations/s, cycle/s, rev/sec

- *Amplitude* is maximum distance from mean position
- *Angular frequency* is $\omega = 2\pi/T \rightarrow \omega = 2\pi f$
- *Phase* is the angle which specifies the displacement and direction of motion of the point executing SHM i.e phase = $\theta = \omega t$
- Initial angle at t = 0 is called *phase constant* and denoted by φ
- If phase constant $\phi = 90^0$, then displacement $x = x_0 \sin(\omega t + 90^0) = x_0 \cos \omega t$, and simple harmonic oscillator starts its SHM from positive extreme position.

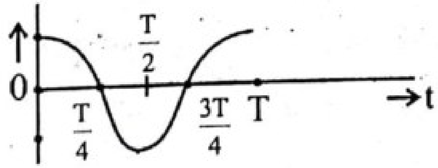
A HORIZONTAL MASS-SPRING SYSTEM

- For spring, Hooke's law states that;
  strain ∝ stress (within elastic limits)
  $F = k\,x$
  Where $k=\dfrac{F}{x}$ is called spring constant or force constant.
  If a spring is cut into two equal parts then spring constant of each spring is doubled.
- *Mass attached to spring has SHM.* $a=-\dfrac{k}{m}x$
  For spring mass system doing SHM $\omega=\sqrt{\dfrac{k}{m}}$
  $a \propto -x$
- Mass-spring system has S.H.M and we can trace its waveform (pictorial display between time and displacement for S.H.M) by following relation;

$$x = x_o \sin\left[\frac{2\pi}{T}\right]t$$



Time t	Position $x(t)$	Velocity $v(t)$	Accel. $a(t)$	KE	PE
0	x_{max}	0	$-a_{max}$	0	PE_{max}
$\frac{T}{4}$	0	$-v_{max}$	0	KE_{max}	0
$\frac{T}{2}$	$-x_{max}$	0	a_{max}	0	PE_{max}
$\frac{3T}{4}$	0	v_{max}	0	KE_{max}	0
T	x_{max}	0	$-a_{max}$	0	PE_{max}



Spring in Series

The resultant of spring constant in case of the series combination is

$$\frac{1}{k}=\frac{1}{k_1}+\frac{1}{k_2}+\ldots\ldots\ldots\ldots\ldots$$

Spring in Parallel

The resultant of spring constant in case of the parallel combination is

$$k = k_1 + k_2 + \ldots\ldots\ldots\ldots\ldots$$

This behaviour of springs resembles with capacitances in series and in parallel combinations.

- *Time period* of single mass attached to spring is given as; $T = 2\pi\sqrt{\frac{m}{k}}$

$T \propto \sqrt{m}$ $\qquad T \propto \frac{1}{\sqrt{k}}$

Its displacement is given as; $x = x_0 \sin \omega t$

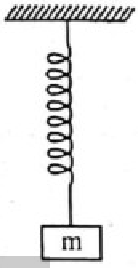
- *Instantaneous velocity* of mass 'm' attached to a spring is given as;

$$V_{ins} = \sqrt{\frac{k}{m}\left(x_o^2 - x^2\right)} = \sqrt{\frac{k}{m}}\, x_o \sqrt{1-\frac{x^2}{x_0^2}} = v_{max}\sqrt{1-\frac{x^2}{x_o^2}}$$

- *Maximum speed* of mass attached to spring is given as;

$$V_{max} = V_o = x_o\sqrt{\frac{k}{m}}$$

- Instantaneous velocity of spring – mass system doing SHM is proportional to constant of proportionality being the maximum velocity. $\sqrt{1-\frac{x^2}{x_o^2}}$



- **In case of vertical spring $F = mg = kx$**

$\therefore$ $\frac{m}{k} = \frac{x}{g}$ (Here x is elongation)

- Then time period $T = 2\pi\sqrt{\frac{x}{g}}$

Velocity	At mean position max	At extreme position zero
Acceleration	At mean position is minimum	At extreme positions is maximum

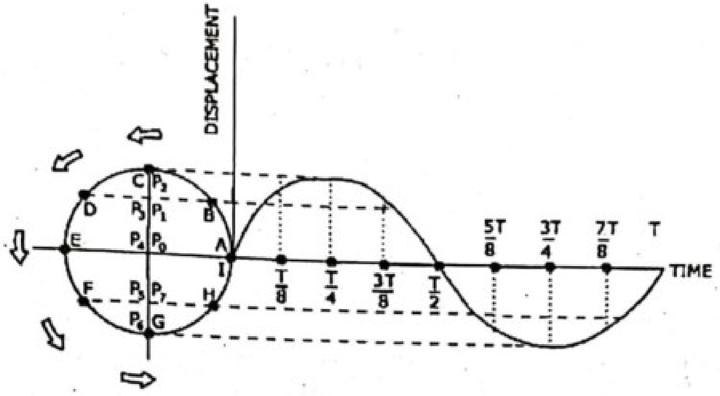
Do you know?
In a one complete vibration a body covers a distance equal to four times of the amplitude.

MOTION OF PROJECTION OF A BODY MOVING IN A CIRCLE ON DIAMETER

- Motion of projection of a body moving in a circle, on the diameter with constant speed is S.H.M
- Its *acceleration* is given as; $a = -\omega^2 x$
- *Time period* of projection is given as; $T = \frac{2\pi}{\omega}$
- *Speed of projection* is given as;

$V = \omega\sqrt{r^2 - x^2}$ where r = radius of the circle = amplitude of S.H.M

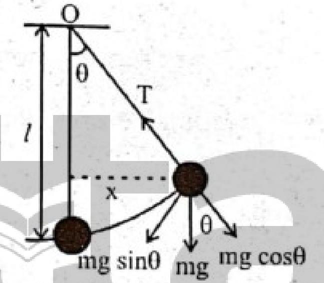
- *Projection speeds up when moving towards the centre of circle.*
- *Projection slows down when moving away from the centre of circle.*
- If speed ω of body in circular motion is not constant then projection does not have S.H.M but has vibratory motion, which is non-S.H.M.



SIMPLE PENDULUM

It consists of a heavy point mass suspended from a rigid support by means of almost weightless and inextensible string.

- *Galileo invented simple pendulum.*
- Motion of simple pendulum is S.H.M if there is no damping.
- Damping force reduces the amplitude of simple pendulum continuously and finally its motion is stopped.



- In absence of damping force, *restoring force* on simple pendulum is given as; $F_r = -mg\sin\theta$, and for small amplitude oscillations $F_r = -mg\theta$.
- Equation of *acceleration* of simple pendulum for small amplitude is;

  $$a = -\left(\frac{g}{l}\right)x$$

  Thus $\omega = \sqrt{\frac{g}{l}}$ for simple pendulum and does not depend on mass like the mass-spring system does.
- *Time period and frequency* of simple pendulum are given as;

  $$T = 2\pi\sqrt{\frac{l}{g}} \text{ and } f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

- If amplitude of simple pendulum is not small then, it has non-S.H.M as $a = -g\sin\theta$ and we know that $\sin\theta = \theta$ only when θ is small.
- **Pendulum Suspended in a Lift:** If the pendulum is suspended in a lift ascending up with uniform acceleration 'a' then its time-period is $T = 2\pi\sqrt{\frac{l}{g+a}}$
- If the pendulum is suspended in a lift descending down with acceleration 'a' then
- $T = 2\pi\sqrt{\frac{l}{g-a}}$

POINT TO PONDER

The time period of simple pendulum is independent of its mass and its amplitude.

Kinds of pendulum

(a) simple pendulum
(b) compound pendulum or physical pendulum
(c) torsion pendulum

- A second pendulum has following characteristics:

Time period	***2 seconds***
Frequency	***0.5 Hz***
Length	***0.99 or 1 meter***

ENERGY CONSERVATION IN SHM

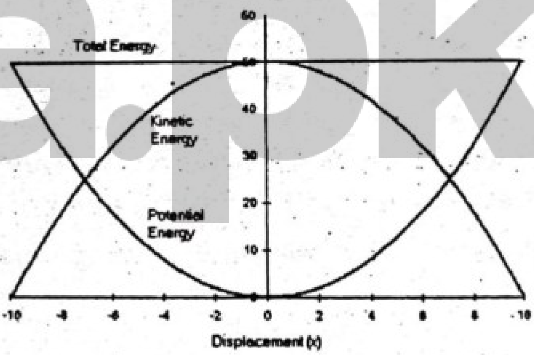
- Its K.E is given as;

$$K.E_{inst} = \frac{1}{2} k x_o^2\left(1-\frac{x^2}{x_o^2}\right)$$

$(K.E)_{max} = \frac{1}{2}kx_o^2$ It is at mean position.

$(K.E)_{min} = 0$ It is at extreme position.

$$K.E_{inst} = (K.E)_{max}\left(1-\frac{x^2}{x_o^2}\right)$$



- Its P.E is given as;

$$P.E_{inst} = \frac{1}{2}kx^2$$

$$(P.E)_{max} = \frac{1}{2}kx_o^2$$

It is at extreme position.

$(P.E)_{min} = 0$

It is at mean position.

- Total energy of system $= \frac{1}{2}kx_o^2$ energy remain conserve in SHM In one vibration K.E. attains its maximum value twice.

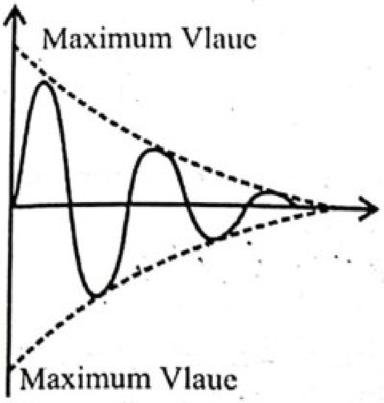
FREE & FORCED OSCILLATIONS

- Oscillation of a system is called free *vibration* if it oscillates without the interference of an external force.
- Frequency of free oscillation is called *natural frequency of the system*
- When a system performs oscillation in the presence of external periodie force its vibration is called *forced oscillation.*
- A physical system under going forced vibration is known as driven harmonic oscillator.

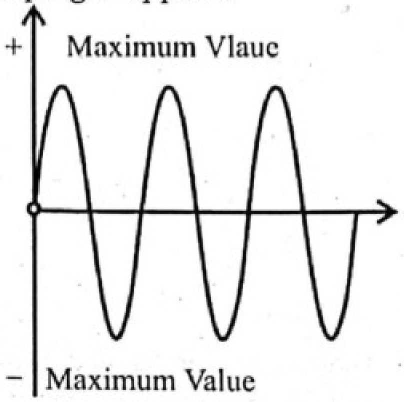
DAMPED OSCILLATION

Such oscillations in which the amplitude decreases steadily with time are called as damped oscillations.

- In shock absorber of a car critical damping is applied.

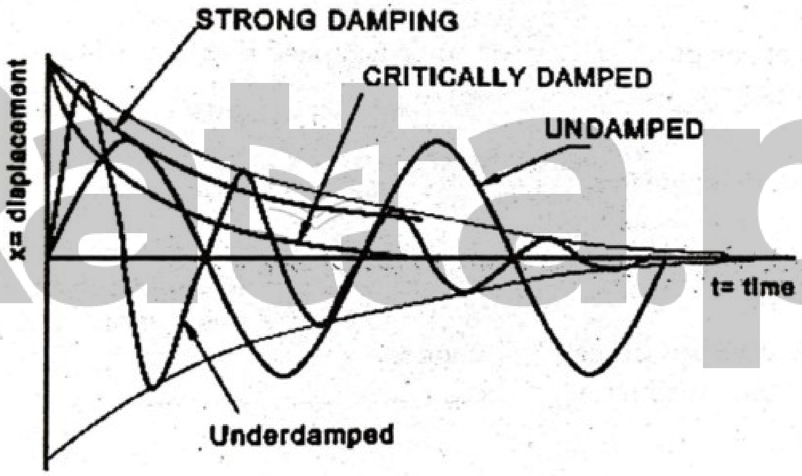


(a) Damped Oscillations



(b) Undamped or Sustained Oscillations

- ***For Information***



RESONANCE

Phenomenon of increase in amplitude of a body (capable of vibrating) under the action of a periodic force whose time period is equal to natural time period of body.

OR

Specific response of a system to external periodic force whose time period is equal to natural time period of a body.

OR

Process in which one body transfers its vibrations to nearby body whose natural time period is agreeable to it.

> **Do you know?**
> Damping is a process where by energy is dissipated from the oscillating system.

- For tuning circuit of T.V or radio or mobile phone, electrical resonance takes place at following frequency;

$$f = \frac{1}{2\pi\sqrt{LC}}$$

- Magnetic resonance imaging is a resonance phenomenon using radio frequency waves. Magnetic field. It is less damaging than X-rays imaging process.
- Suspension bridge may break down due to vibration with increased amplitude caused by resonance.
- We get tired on walking briskly because of forced oscillations fed into our legs for resonance.
- Loose parts of car produce noise at specific speed due to resonance.

SHARPNERS OF RESONANCE

- Amplitude of vibration decreases with damping force
- Amplitude of vibration remain constant with undamped force
- Smaller the damped force, sharper is the resonance and vice – versa.

> **Do you know?**
> A microwave oven generates high frequency waves, which heat up water and fat molecules by large energy absorption, and hence food is cooked.

PRACTICE EXERCISE

30 mins
Time Yourself

(1) **In vibratory motion**
(a) P.E. remains constant
(b) K.E. remain constant
(c) total energy remain constant
(d) total momentum remain constant

Imp

(2) **The waveform of S.H.M. is**
(a) standing wave
(b) sine wave
(c) square wave
(d) rectangular waves

(3) **An oscillatory motion must be simple harmonic if:**
(a) the motion is along the arc of a circle
(b) the potential energy is equal to the kinetic energy
(c) the acceleration varies sinusoidally with time
(d) the amplitude is small

(4) **In S.H.M, the velocity of a particle is maximum at**
(a) mean position
(b) extreme position
(c) middle between mean and extreme position on the right side
(d) middle between mean and extreme position on the left side.

(5) **The acceleration of a projection on the diameter for a particle moving along a circle is**
(a) $\omega^2 x$
(b) ωx^2
(c) $-\omega^2 x$
(d) $-\omega x^2$

(6) **Total energy of a body executing S.H.M, is directly proportional to**
(a) square root of amplitude
(b) the amplitude
(c) reciprocal of amplitude
(d) square of amplitude

(7) **The time period of a second's pendulum is**
(a) 4 seconds
(b) 3 seconds
(c) 2 seconds
(d) 6 seconds

(8) **The length of simple pendulum on the surface of earth is 1m, its length on the surface of the moon, where g is $1/6^{th}$ value of g on the earth is**
(a) Remain same
(b) 6m
(c) 1/6m
(d) 1/36m

(9) **If length of a pendulum becomes four times, then its time period will become**
(a) four times
(b) six times
(c) eight time
(d) two times

(10) **The force responsible for the vibratory motion of the simple pendulum is**
(a) mg sinθ
(b) mg cosθ
(c) mg tanθ
(d) mg

(11) **The tension in the string of simple pendulum is**
(a) constant
(b) maximum at the extreme position
(c) maximum at the mean position
(d) zero at the mean position

(12) **The waves produced in microwave oven have wavelength of**
(a) 12 m
(b) 1.2 cm
(c) 12 cm
(d) 12 μm

Imp

(13) **The SI unit of force constant is identical with that of**
(a) force
(b) pressure
(c) surface tension
(d) loudness

(14) When the amplitude of a SHM become double, its energy become

(a) double (b) four times
(c) one half (d) none time

(15) A particle oscillating in simple harmonic motion is

(a) never in equilibrium because there is always a force
(b) never in equilibrium because it is in motion
(c) in equilibrium at the center of its path because the acceleration is zero there (d) in equilibrium at the ends of its path because its velocity is zero there

(16) The energy of SHM is maximum at

(a) mean position (b) extreme position
(c) in between mean and extreme (d) all positions during SHM

(17) If a hollow bob of a simple pendulum be filled with mercury that drains out slowly, its time period

(a) increases continuously (b) decreases continuously
(c) remain same (d) first increases then decreases

(18) Which one is the correct graph between acceleration 'a' and displacement 'x' for SHM?

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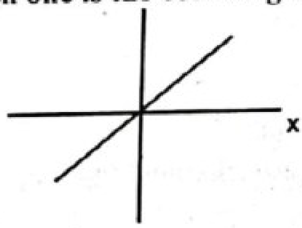
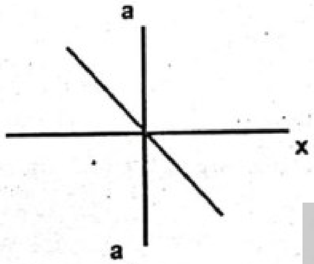
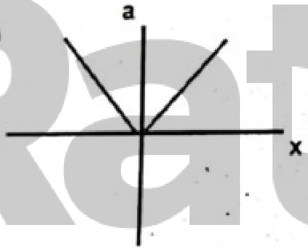
(a)



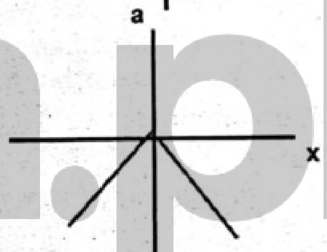
(b)



(c)



(d)



(19) The displacement of SHM is written as $x = x_0 \sin\omega t$. If displacement is written by $x = x_0 \cos\omega t$ then phase constant will be equal to

(a) 0° (b) 45°
(c) 90° (d) 180°

(20) For what displacement the P.E of SHM becomes 1/4 of its maximum value?

(a) $x = x_0$ (b) $x = x_0/2$
(c) $x = x_0/4$ (d) $x = x_0^2/2$

(21) K.E and P.E of a spring mass system executing SHM become equal at which displacement? (A being the amplitude)

(a) $\pm\sqrt{2}A$ (b) $\pm\frac{1}{\sqrt{2}}A$
(c) $\pm\frac{1}{2}A$ (d) $\frac{1}{\sqrt{2}}A$

(22) When a body executes simple harmonic motion, its acceleration at the ends of its path must be:

Imp

(a) zero (b) greater than g
(c) less than g (d) none of these

(23) **Which of the given equation is correct in SHM**

(a) T.E = $\frac{1}{2}kx_o^2$
(b) T.E = $K.E_{max}$
(c) T.E = $P.E_{max}$
(d) all are correct

(24) **Phase of SHM describes**

(a) displacement only
(b) direction of motion only
(c) both displacement and direction of motion
(d) neither displacement nor direction of motion

(25) **Natural frequency of simple pendulum depends upon**

(a) its mass
(b) its length
(c) square of its length
(d) square root of its length

(26) **The amplitude and phase constant of an oscillator are determined by:**

(a) both the initial displacement and velocity
(b) the initial velocity alone
(c) the initial displacement alone
(d) the angular frequency

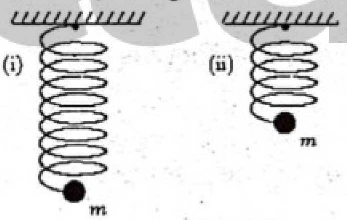
(27) **Total distance traveled by bob of simple pendulum in one vibration is equal to**

(a) amplitude
(b) square of amplitude
(c) twice of amplitude
(d) four times of amplitude

(28) **When K.E of SHM is maximum, its**

(a) P.E is zero
(b) acceleration is zero
(c) restoring force is zero
(d) all P.E acceleration & restoring force are zero

(29) **A simple harmonic oscillator consists of an particle of mass m and an ideal spring with spring constant k. Particle oscillates as shown in (i) with period T. If the spring is cut in half and used with the same particle, as shown in (ii), the period will be**

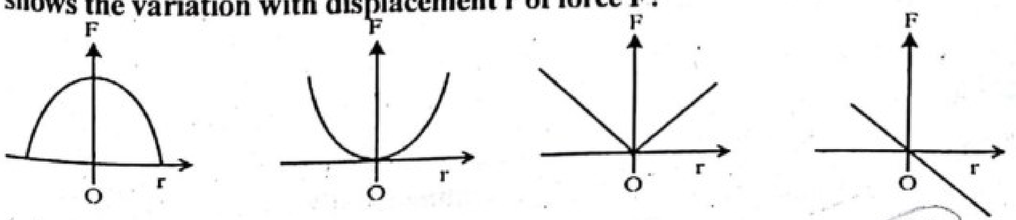


(a) T
(b) T/2
(c) $\frac{T}{\sqrt{2}}$
(d) 2T

(30) **Forced vibrations are known as**

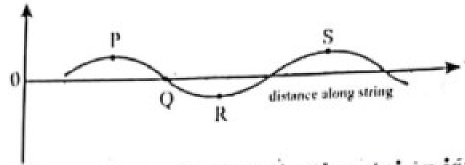
(a) simple harmonic vibration
(b) natural vibration
(c) driven harmonic vibration
(d) free vibration

(31) **A resultant force F acts on a particle moving with simple harmonic motion. Which graph shows the variation with displacement r of force F?**



(a) (b) (c) (d)

(32) The graph shows the shape at a particular instant of part of a transverse wave traveling along a string.



Which statement about the motion of points in the string is correct?

(a) The speed at point P is a maximum
(b) The displacement at point Q is always zero
(c) The energy at point R is entirely kinetic
(d) The acceleration at point S is a maximum

(33) A simple harmonic oscillator has a time period of 10 seconds. Which equation relates is acceleration a and displacement x?

(a) $a=-10x$
(b) $a=-\left(\frac{2\pi}{10}\right)^2 x$
(c) $a=-(20\pi)^2 x$
(d) $a=-(20\pi)x$

(34) The projection of the particle moving in a circle with non-uniform angular speed executes.

(a) S.H.M
(b) Vibratory motion
(c) Both (b) and (d)
(d) Non S.H.M

(35) If an oscillator starts vibrating from negative extreme, its phase constant will be

(a) $\frac{\pi}{2}$ rad
(b) π rad
(c) $\frac{3\pi}{2}$ rad
(d) 0°

(36) For a simple pendulum the restoring force is caused by

(a) gravity
(b) spring
(c) hand
(d) all of these

(37) The distance covered by a body in one complete vibration is 20cm. What is the amplitude of body

A+A+A+A = 4A

(a) 10cm
(b) 5cm
(c) 15cm
(d) 7.5cm

(38) If the mass of the spring-mass oscillator become half the squared frequency will be

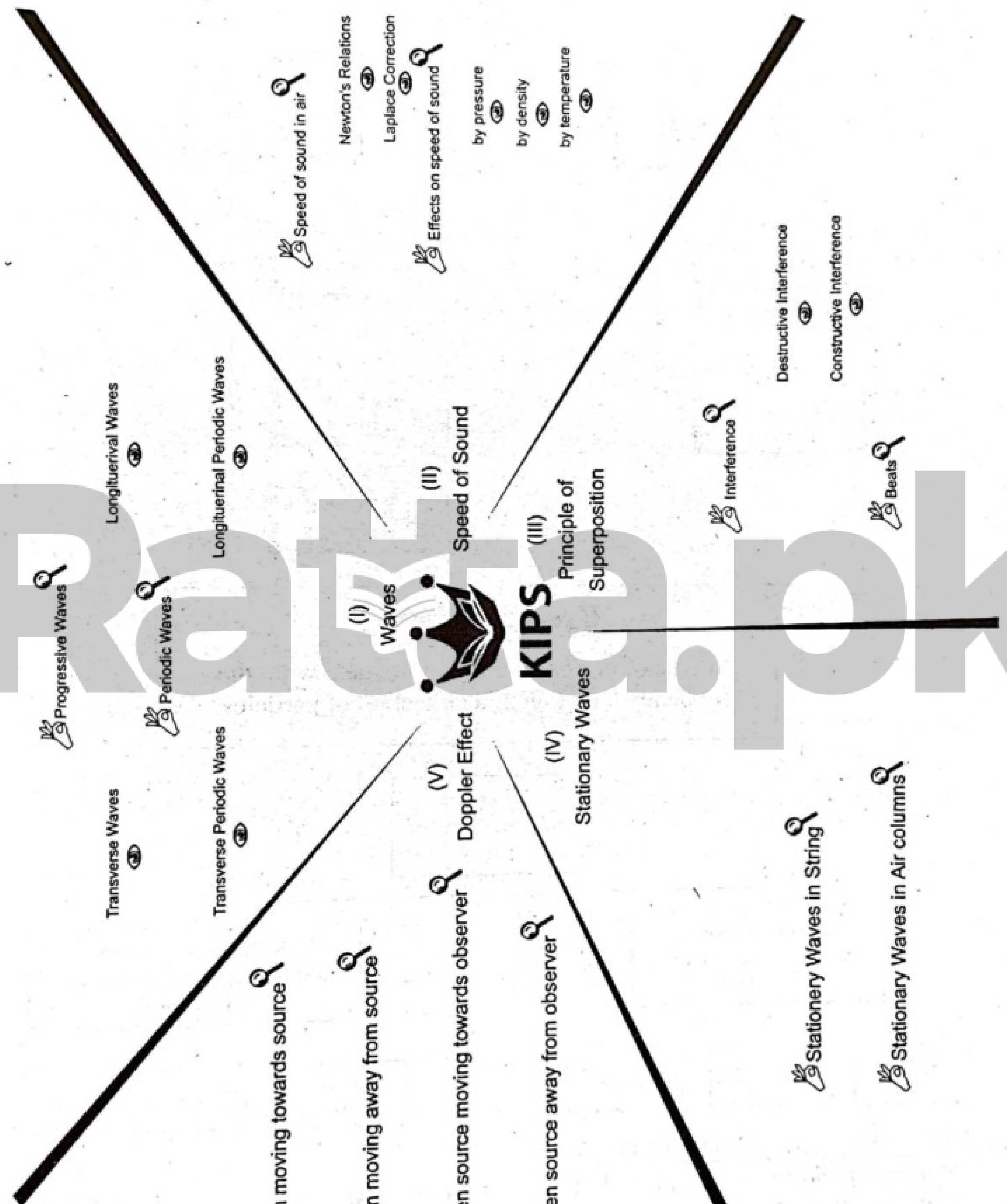
(a) Quadruple
(b) Half
(c) double
(d) remain same

(39) In case of a simple pendulum, the cause of damping is

(a) drag force of air
(b) gravity
(c) tension in string
(d) none of these

(40) The energy absorbed by a body is ______________ at resonance.

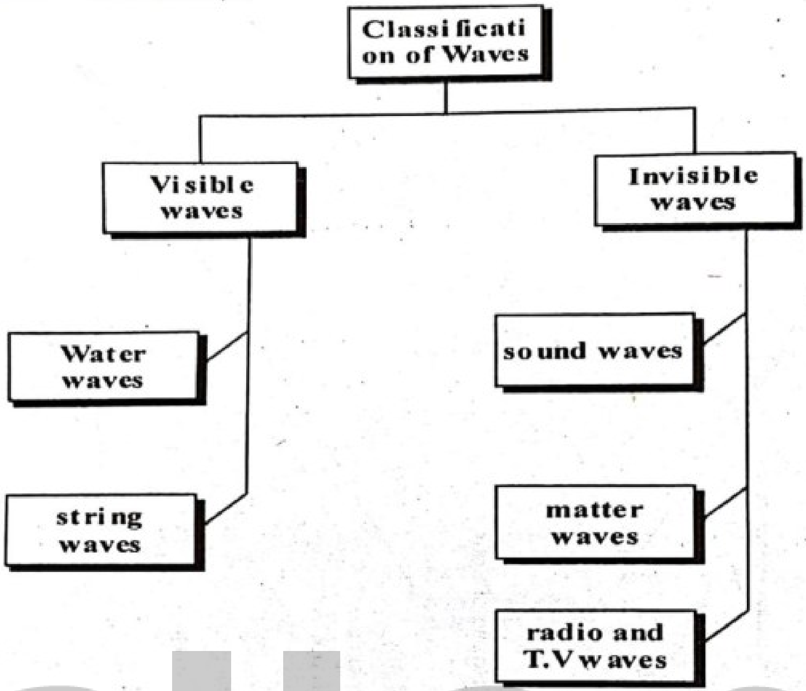
(a) maximum as well minimum
(b) minimum only
(c) maximum only
(d) zero


KIPS
(I) Waves
Progressive Waves
Longituerival Waves
Transverse Waves
Periodic Waves
Longituerinal Periodic Waves
Transverse Periodic Waves
(II) Speed of Sound
Speed of sound in air
Newton's Relations
Laplace Correction
Effects on speed of sound
by pressure
by density
by temperature
(III) Principle of Superposition
Interference
Destructive Interference
Constructive Interference
Beats
(IV) Stationary Waves
Stationery Waves in String
Stationary Waves in Air columns
(V) Doppler Effect
When moving towards source
When moving away from source
When source moving towards observer
When source away from observer

INTRODUCTION

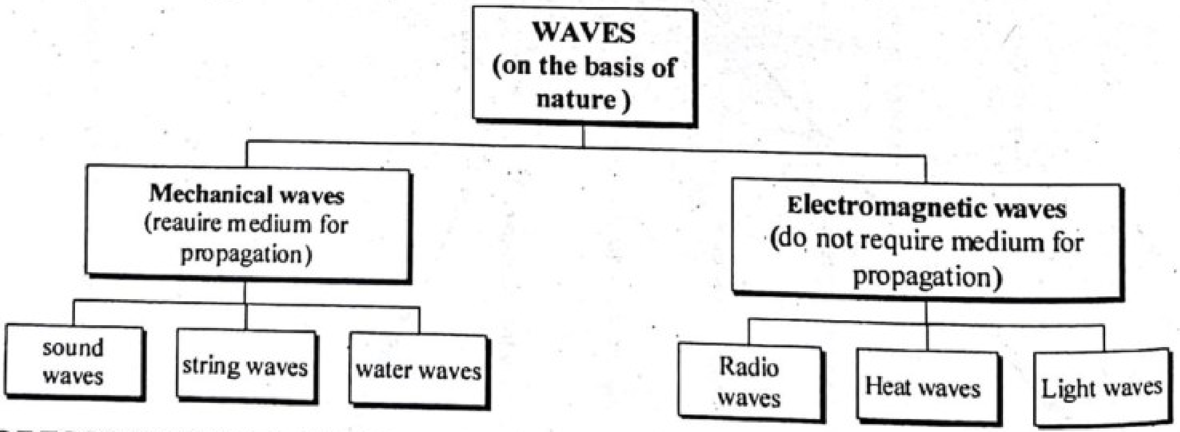
- *Wave is due to disturbance created in a medium.*
- Waves transport energy without transporting matter.

CLASSIFICATION OF WAVES



Do you know?

In case of mechanical waves we deal with the cooperative motion of a collection of particles.



PROGRESSIVE/TRAVELING WAVES

- *Traveling wave* is that which propagates or distributes its pulses in space along specific direction. e.g.

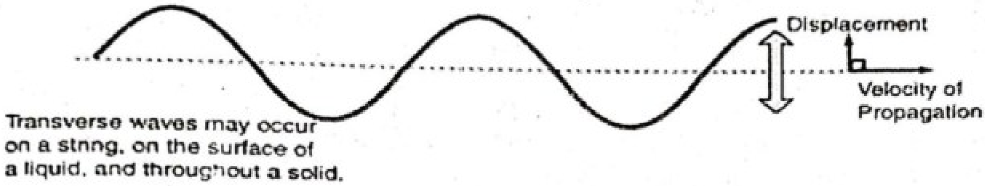
(i) Waves on a string

(ii) Waves on a water surface

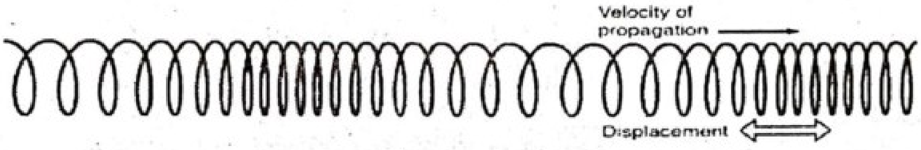
PERIODIC WAVES

Periodic waves are those, which are repeated in regular interval of time

- Periodic wave may be transverse or longitudinal.
- For transverse waves the displacement of the medium is perpendicular to the direction of propagation of the wave. A ripple in a pond and a wave on a string are easily visualized as transverse waves.



Transverse waves cannot propagate in a gas or a liquid because there is no mechanism for driving motion perpendicular to the propagation of the wave.
In longitudinal waves the displacement of the medium is parallel to the propagation of the wave. A wave in a "slinky" is a good visualization. Sound waves in air are longitudinal waves.



In fluids, transverse waves die out very quickly and usually cannot be produced at all.

TRANSVERSE PERIODIC WAVE

- In a time interval equal to time period, a particle in the wave travels a distance equal to **wavelength.**
- For all waves $v=f\lambda$
- The particles in the wave separated by a distance which is integral multiple of λ i.e. $n\lambda$ are in phase motion with each other.

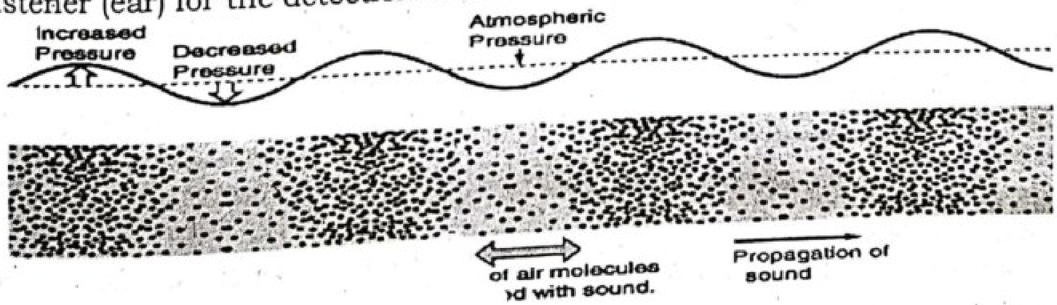
> **Do you know?**
> The waves transport both energy and momentum in a medium.

- The particles separated by a distance which is odd multiple of λ i.e: $\left(n+\frac{1}{2}\right)\lambda$ are **out phase** to each other.

SOUND

- A vibrating body produces sound waves ($\lambda \approx 1\text{m}$).
- Three things are essential for the detection of sound.

(i) Vibrating body for production of sound
(ii) Medium for propagation of sound
(iii) Listener (ear) for the detection of sound



- *Sound waves are longitudinal waves having three dimensional propagation in air.*
- Longitudinal sound waves consist of compressions and rarefactions.
- *Compression* is a region where crowding of particles of medium is maximum.

WAVE	SPEED (m/S)
EM waves	300 000 000
Sound in air	340
Sound in water	1500
Sound in steel	5000

- *Rarefaction* is region where crowding of particles of medium is minimum.
- *Sound waves produce Reflection, Refraction, Diffraction, Interference but not polarization because sound waves are longitudinal.*

SOUND INTENSITY

Sound intensity is defined as the sound power per unit area. The usual context is the measurement of sound intensity in the air at a listener's location. The basic units are watt/m^2 or watt/cm^2.

The most common approach to sound intensity measurement is to use the decibel scale:

$$I(dB) = 10\log_{10}\left[\frac{I}{I_0}\right] \qquad \text{Intensity in decibels}$$

VELOCITY OF SOUND IN AIR

- Speed of any mechanical wave is found by the following formula

  $v = \sqrt{\frac{E}{\rho}}$ where E = modulus of elasticity of medium, ρ=density of medium

- In gases, sound travels in the form of compressional wave; and gases have bulk modulus of elasticity. So for gases, we get-

  $$v = \sqrt{\frac{E_{bulk}}{\rho}}$$

- *Bulk modulus* of elasticity is ratio of stress to volumetric strain

  $$E_{bulk} = \frac{P}{\left(\frac{\Delta V}{V}\right)}$$

- Newton proved that for air **the isothermal modulus of elasticity is** $E_{bulk}=P$, and speed of sound is $V = \sqrt{\frac{P}{\rho}}$

- At S.T.P the speed of sound in air is

  $v = \sqrt{\frac{hdg}{\rho}}$ (where d = density of mercury)

  $$v = \sqrt{\frac{76\times13.6\times981}{0.001293}}$$

  $= 28100$ cm/s

  $= 281$ m/s

Whereas experimental value is 332 ms^{-1}.

- *Percentage error in Newton's calculation was 16%* because of assumption that sound propagate through air isothermally.

- *Laplace corrected Newton's formula by proposing that "sound wave does not propagates in air isothermally but adiabatically."*
- Laplace's formula is given as;

$$v = \sqrt{\frac{\gamma P}{\rho}} \quad \text{where } \gamma P = E_{\text{bulk modulus}} = \text{adiabatic elastic modulus of fluid.}$$

$$\gamma = \frac{C_p}{C_v} = 1.42 \text{ (for air)}$$

- *Experimentally it is found that speed of sound increases by 0.61 ms^{-1} or 61 cms^{-1} for each 1°C rise in temperature.*

Effect of moisture

Water vapours are lighter than air, thus the presence of moisture in air reduces density and hence the speed of sound increases in such cases.

Dependence of velocity of sound

(i) V is independent of pressure

(ii) $v \propto \frac{1}{\sqrt{\rho}}$

(iii) $v \propto \sqrt{T}$

(iv) $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$

(v) $v_t = v_o + 0.61t$

Do you know?

The speed of sound in hydrogen is four times more than the speed of sound in oxygen at same temperature

PRINCIPLE OF SUPERPOSITION

When two or more waves reach a point of the medium simultaneously then the resultant displacement at that point of the medium is equal to sum of the individual displacements produced by each wove. This is called principle of superposition

$$Y_{total} = Y_1 + Y_2\ Y_3 + \dots\dots + Y_n$$

APPLICATIONS

Interference:

It is produced by superposition of *two waves of same frequencies, which are traveling in the same direction.*

Beats:

These are produced by two waves of slightly different frequencies traveling in the same direction

Stationary Waves:

These are produced by two waves of equal frequency and equal amplitude traveling along same line in opposite direction.

INTERFERENCE OF SOUND

Superposition (mixing up) of two identical sound waves while passing through same medium propagating along same direction is called their interference.

Conditions for interference

(i) coherent waves
(ii) same medium
(iii) same direction
(iv) identical waves
(v) Sources of sound should be close to each other

- *In constructive interference,* two interfering sound waves reinforce each other, so that the resultant is a louder sound.

Condition for constructive interference

Path difference = nλ where n = 0, ±1, ±2, ...

- *In destructive interference*, two interfering sound cancel each other's effect, so that the resultant loudness of sound wave is become fainter.

Condition for destructive interference

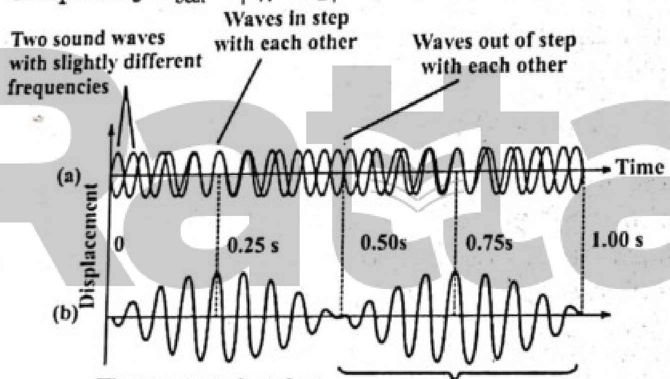
Path difference $= \left(n + \frac{1}{2}\right)\lambda$ *where n = 0, ±1, ±2, ...*

- *Echoing zone* is region of constructive interference
- *Silence zone* is region of destructive interference
- *Path difference* is the difference between lengths of paths traveled by two waves in reaching the same point.

BEATS

The periodic alterations of sound between maximum and minimum loudness are called beats

- Beats are produced by the super position of two waves having slightly different frequencies traveling in same medium along same direction.
- *Beat frequency* is defined as number of beats per second.
- Absolute difference between frequencies of producing beats is equal to beat frequency $f_{beat} = |f_A - f_B|$



The two waves interfere constructively when they are in step and destructively when they are a half-cycle out of step. The resultant wave waxws and wanes in intensity, forming beats.

Do you know?

If frequency of a tuning fork is 32 Hz then after 3/4 sec, it will complete 24 vibrations.

Maximum detectable beat frequency for normal human ear is 10Hz.

- Beats are used to:

1- Determine unknown frequencies
2- Tune musical instruments

REFLECTION OF WAVES

- All kinds of wave shows reflection
- *When reflection of wave takes place from denser boundary, the phase of waves reverses. In this case, reflection co-efficient is maximum and transmission co-efficient is almost zero except for quantum mechanical transmission of particle from potential barrier.*
- *When reflection takes place from rarer boundary, there is no phase reversal. In this case, reflection co-efficient and transmission coefficient have considerable values*

Do you know?

The reflected wave has the same wavelength and frequency but its phase may change depending on the nature of reflecting medium.

TRANSMISSION OF WAVES

- Practically amplitude of transmitted wave is less than that of incident wave because some of energy of incident wave is wasted at point of discontinuity.

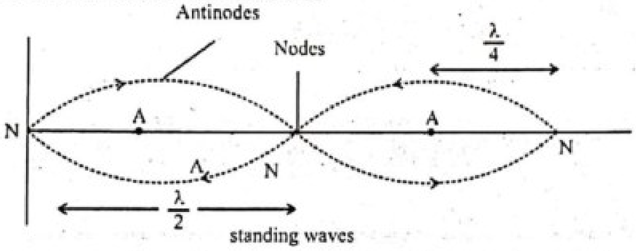
- Frequency of transmitted wave is same as that of incident wave but its velocity depends on density of medium as given below;

$$v \propto \frac{1}{\sqrt{\rho}}$$

- Since velocity of transmitted wave is different from original wave, therefore, wave length (λ) changes as frequencies of both waves are equal

STANDING WAVES

- Super position of two identical waves traveling opposite to each other in the same medium simultaneously, gives rise to stationary or standing waves
- *Both constructive and destructive interference takes place in the formation of stationary waves.*
- Points of constructive interference are called *antinodes* while points of destructive interference are called *nodes* as shown



standing waves

- Amplitude is maximum at antinodes and minimum (zero) at nodes.
- *Nodes* are stationary points whereas *antinodes* are points that vibrate with maximum amplitude.
- *Two consecutive nodes or antinodes are separated by distance equal to $\lambda/2$ and an antinode and its consecutive node by $\lambda/4$.*

Do you know?
The energy stored in anti nodes at their extreme position is wholly potential while at equilibrium position the energy stored is wholly kinetic but total energy remains the same.

STANDING WAVES IN STRECHED STRING

- At fixed end of string always node is formed while at free end of string always antinode is formed.
- If string is fixed at both ends, then number of nodes is one greater than no. of antinodes. **N = A+1**
- *If string is free at one to end, then no. of antinodes is equal to that of nodes.* **A = N**

Do you know?
The speed of stationary waves is independent of the No. of loops.

- *Speed* of string wave is

$$V = \sqrt{\frac{T}{m}} = \sqrt{\frac{F}{m}}$$

m is called linear mass density.

- Only the following quantized frequencies of transverse stationary waves on stretched string can be produced.

$f_n = n f_1, \quad n = 1, 2, 3, \ldots\ldots\ldots\ldots$

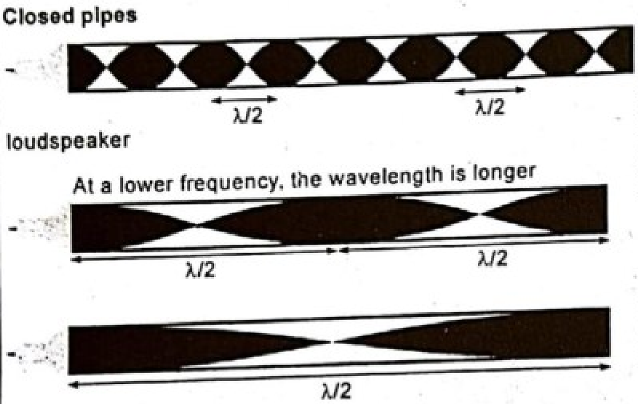
where $\quad f_1 = \frac{1}{2l}\sqrt{\frac{T}{m}}$

f_1 is the lowest frequency (fundamental or basic frequency) at which first stationary wave is formed.
All other frequencies (f_2, f_3,...,f_n) which are integral multiple of fundamental frequencies are called overtones or harmonics.

STANDING WAVES IN AIR COLUMNS

Standing waves in pipes

Closed pipes



A loudspeaker sends a sound into a long tube. Dust in the tube can show nodes and antinodes. Nodes are half a wavelength apart. So are antinodes. Maximum amplitude shows maximum pressure variation and minimum motion of air (pressure antinode). Minimum amplitude shows minimum pressure variation and maximum motion of air (pressure node).

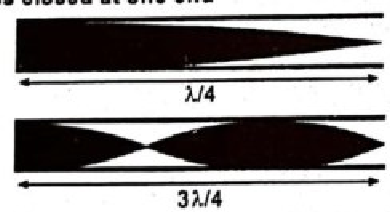
The fundamental: The lowest frequency which can form a standing wave has wavelength equal to twice the length of the tube

Pipes open at both ends

Sound can be reflected from an open end as well as from a closed end.

This is how open organ pipes and flutes work.

Pipes closed at one end



Pipes closed at one end are shorter, for the same note.

A clarinet is like this. An oboe is too, but with a tapered tube.

Some organ pipes are stopped at one end.

Frequencies of standing waves

	pipes open or closed at both ends strings fixed at both ends	pipes open at one end
length L	$L = n\lambda/2$	$L = (2n-1)\,\lambda/4$
fundamental	$f = v/2L$	$f = v/4L$
harmonics	$2f$ $3f$ ... nf	$3f$ $5f$ ... $(2n-1)f$

where n = 1,2,3.......

- *Fundamental frequency of open pipe = 2 × fundamental frequency of closed pipe*
- *No. of harmonics in open pipe = 2 × No. of harmonics in closed pipe*

DOPPLER'S EFFECT

> **Point To ponder**
> The open end of the organ pipe behaves as antinode while the closed end behave as node in case of stationary waves through organ pipe. Why

Appar... source and observer.

- Doppler's effect was discovered by Doppler, an Australian physicist, in 1845.
- *Apparent frequency of sound heard by* ***stationary listener*** *due to source* ***moving towards*** *him at speed 'u_s' is given as;*

$$f' = \left(\frac{v}{v-u_s}\right) f \qquad f' > f$$

- *Apparent frequency of sound heard by* ***stationary listener*** *due to source* ***moving away*** *from him at speed 'u_s' is given as;*

$$f' = \left(\frac{v}{v+u_s}\right) f \qquad f' < f$$

- *Apparent frequency of sound heard by a* ***person moving towards*** *a* ***stationary source with*** *speed 'u_0' is given as;*

$$f' = \left(\frac{v+u_o}{v}\right) f \qquad f' > f$$

- *Apparent frequency of sound heard by a listener* ***moving away from a stationary source with*** *speed 'u_0' is given as;*

$$f' = \left(\frac{v-u_o}{v}\right) f \qquad f' < f$$

- *When source and listener move in same direction, then frequency of sound heard by listener is given as;*

$$f' = \left(\frac{v-u_o}{v+u_s}\right) f$$

Where v = true speed of sound u_o = speed of listener u_s = speed of source

- *When source and observer are moving away from each other, then frequency of sound heard by listener is given as;*

$$f' = \left(\frac{v+u_o}{v-u_s}\right) f$$

- Light observes Doppler's effect too.

Applications of Doppler's effect

(i) Ships and submarine (sonar devices)
(ii) Bats (for traveling)
(iii) Radar (for detection)
(iv) Determining velocity of a star w.r.t earth
(v) to monitor blood flow in major arteries.

- When a star is moving away from Earth then wavelength of light increases and red shift of spectrum is observed
- When a star is moving towards the Earth then wavelength of light decreases and blue shift of spectrum is observed

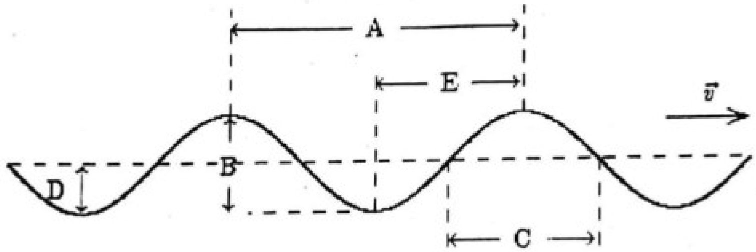
PRACTICE EXERCISE

30 mins Time Yourself

(1) Which of the following is not the property of sound?
(a) It can travel in vacuum
(b) It is reflected
(c) It shows phenomenon interference
(d) It is propagated as longitudinal wave

(2) The waves that require a material medium for their propagation are called
(a) matter waves
(b) electromagnetic waves
(c) carrier waves
(d) mechanical waves

(3) A sinusoidal wave is traveling toward the right as shown. Which letter correctly labels the amplitude of the wave?



(a) A
(b) D
(c) B
(d) C

(4) When two identical traveling waves are superimposed, the velocity of the resultant wave
(a) decreases
(b) increases
(c) remains unchanged
(d) becomes zero

(5) In vibrating cord the points where the amplitude is maximum, are called
(a) antinodes
(b) nodes
(c) troughs
(d) crests

(6) Echo is the phenomenon of
(a) interference of sound
(b) reflection of sound
(c) refraction of sound
(d) none of these

(7) The speed of a sinusoidal wave on a string depends on
(a) the length of the string
(b) the tension in the string
(c) the wavelength of the wave
(d) the frequency of the wave

(8) If stretching force T of wire increases, then its frequency
(a) decreases
(b) increases
(c) remains the same
(d) any of above

(9) A stationary wave is set up in the air column of a closed pipe. At the closed end of the pipe
(a) always a node is formed
(b) always an antinode is formed
(c) neither node nor antinode is formed
(d) sometimes a node and sometimes an antinode is formed

(10) A source of frequency f sends waves of wavelength λ traveling with speed v in some medium. If the frequency is changed from f to 2f, then the new wavelength and new speed are (respectively):
(a) 2λ, v
(b) $\lambda/2$, v
(c) λ, 2 v
(d) λ, v/2

(11) According to Newton sound travel in air under the conditions of which type of process?
(a) adiabatic
(b) isothermal
(c) isobaric
(d) isochoric

(12) **Beats are a result of**
(a) Diffraction
(b) Constructive interference
(c) Destructive interference
(d) Alternate constructive and destructive interference

(13) **Velocity of sound in vacuum is**
(a) 332 ms^{-1} (b) 320 ms^{-1}
(c) Zero (d) 224 ms^{-1}

(14) **Increase in velocity of sound in the air for 1°C rise in temperature is**
(a) 1.61 ms^{-1} (b) 61.0 ms^{-1}
(c) 0.61 ms^{-1} (d) 2.00ms^{-1}

(15) **Energy is not transferred by**
(a) Longitudinal wave (b) Transverse waves
(c) Stationary waves (d) Electromagnetic waves

(16) **On loading the prong of a tuning fork with wax, its frequency**
(a) increases (b) decreases
(c) remains unchanged (d) may increase or decrease

(17) **The velocity of sound in air would become double than its velocity at 0°C at temperature**
(a) 313°C (b) 586°C
(c) 819°C (d) 1172°C

(18) **Fully constructive interference between two sinusoidal waves of the same frequency occurs only if they**
(a) travel in opposite directions and are in phase
(b) travel in the same direction and are in phase
(c) travel in opposite directions and are 180° out of phase
(d) travel in the same direction and are 180° out of phase

(19) **For ultrasonic waves**
(a) frequency is in the audible range (b) frequency is greater than 20 kHz
(c) frequency lower than 20 Hz (d) all of above

(20) **A string, clamped at its ends, vibrates in three segments. The string is 100cm long. The wavelength is:**
(a) 33.3cm (b) 150cm
(c) 66.7cm (d) 300cm

(21) **The number of beats produced per second is equal to**
(a) the sum of the frequencies of two tuning forks
(b) the difference of the frequencies of two tuning forks
(c) the ratio of the frequencies of two tuning forks
(d) the frequency of either of the two tuning forks

(22) **A wave in soft string reflects from a hard steel rod. Its phase difference relative to incident wave will be**
(a) 0° (b) 90°
(c) 180° (d) 76°

(23) **Silence zone takes place due to**

(a) constructive interference (b) destructive interference

(c) beats (d) resonance

(24) **Doppler effect applies to**

(a) sound wave only (b) light wave only

(c) both sound and light waves (d) neither sound nor light wave

(25) **An organ pipe with one end closed and the other open has length L. Its fundamental frequency is proportional to:**

(a) L (b) 1/L

(c) L^2 (d) $\sqrt{L}$

(26) **To monitor blood flow through major arteries, ultrasonic waves of which frequencies are employed?**

(a) 5 to 10 Hz (b) 5 to 10 MHz

(c) 15 – 100 MHz (d) None of these

(27) **Which one is the correct relation for fundamental frequency of open and closed pipe?**

myself

(a) $f_{open} = 2\ f_{closed}$ (b) $f_{closed} = 2f_{open}$

(c) $f_{open} = f_{closed}$ (d) $f_{open} = 1/\ f_{closed}$

(28) **In open organ pipe**

(a) only even harmonics are present (b) only odd harmonics are present

(c) both even and odd harmonics are present (d) selected harmonics are present

(29) **Which one is the correct relation for speed of sound?**

(a) $V_{Newton} = V_{Laplace}$ (b) $V_{Newton} = \gamma V_{Laplace}$

(c) $V_{Newton} = \sqrt{\gamma}\ V_{Laplace}$ (d) $V_{Laplace} = \sqrt{\gamma}\ V_{Newton}$

(30) **Progressive waves of frequency 300 Hz are superimposed to produce a system of stationary waves in which adjacent nodes are 1.5 m apart. What is the speed of the progressive waves?**

(a) $100\ ms^{-1}$ (b) $900\ ms^{-1}$

(c) $450\ ms^{-1}$ (d) $200\ ms^{-1}$

(31) **A source of sound moves towards a stationary observer with a speed one third that of sound. If the frequency of the sound from the source is 100 Hz, the apparent frequency of the sound heard by the observer is**

(a) 67 Hz (b) 100 Hz

(c) 150 Hz (d) 75 Hz

(32) **The source is moving towards a stationary observer then the pitch of the sound will**

(a) Sometimes increases and some times decreases

(b) Remains constant

(c) Decrease

(d) Increase

(33) **Newton formula estimated the speed of sound**

(a) 281 ms^{-1} (b) 333 ms^{-1}

(c) 340 ms^{-1} (d) all of the above

(34) **Laplace found that the alternate compressions and rarefactions produced in sound waves follow**

(a) isothermal law (b) adiabatic law

(c) isochoric law (d) all of the above

(35) **For destructive interference of sound waves the path difference between two interfering sounds should be**

(a) $n\lambda$ (b) $\left(n+\frac{1}{2}\right)\lambda$

(c) some time $n\lambda$ and some times $\left(n+\frac{1}{2}\right)\lambda$ (d) none of these

(36) **The speed of sound in hydrogen is _____________time than that in oxygen**

(a) Two times (b) Three times

(c) Four time (d) Six time

(37) **The beats frequency (sensible) for a human ear is**

(a) 24Hz (b) 10Hz

(c) 12Hz (d) 16Hz

(38) **The speed of stationary waves in a stretched string are independent of**

(a) Number of loops (b) Tension in the string

(c) Point where string is plucked (d) Both (a) and (c)

(39) **The audible frequency range will be maximum for**

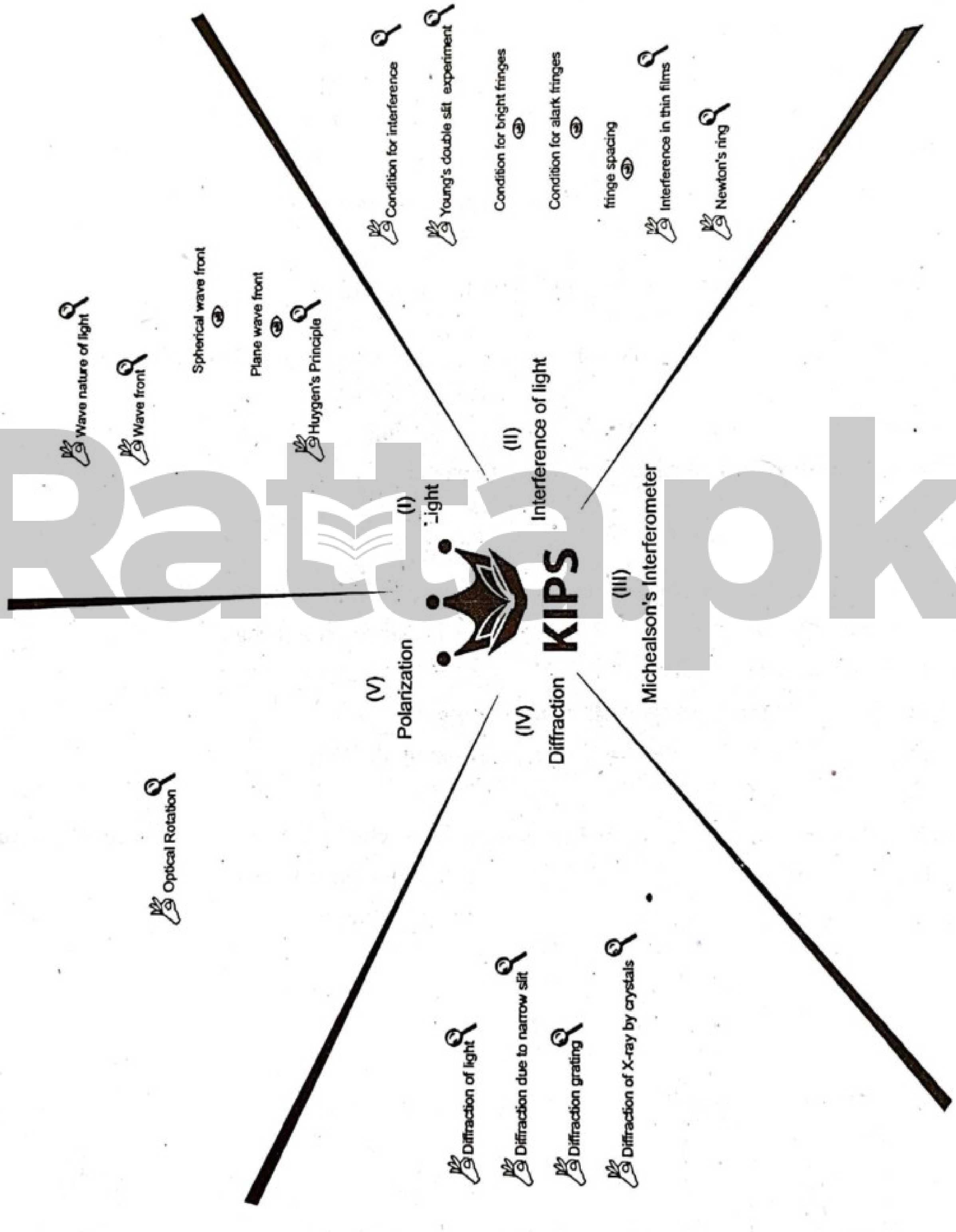
(a) Dog (b) Dolphin

(c) Bat (d) Cat

(40) **Which phenomena can be applied to estimate the velocity of star with respect to Earth**

(a) Doppler's effect (b) Interference of waves

(c) Beats phenomena (d) All of these


KIPS
(I)
Light
Wave nature of light
Wave front
Spherical wave front
Plane wave front
Huygen's Principle
(II)
Interference of light
Condition for interference
Young's double slit experiment
Condition for bright fringes
Condition for dark fringes
fringe spacing
Interference in thin films
Newton's ring
(III)
Michealson's Interferometer
(IV)
Diffraction
Diffraction of light
Diffraction due to narrow slit
Diffraction grating
Diffraction of X-ray by crystals
(V)
Polarization
Optical Rotation

WAVE FRONT AND RAYS

- *Wave front* is a locus of points which have same phase of vibrations.
- Following are the types of wave front;

Spherical wave front:

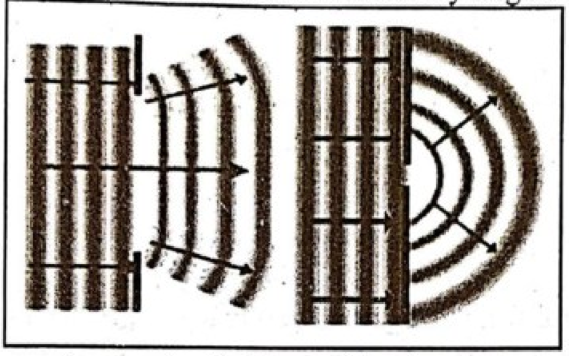
Set of points, which determine the surface of sphere.

Cylindrical wave front:

Set of points, which determine the surface of cylinder.

Plane wave front:

A small part of spherical or cylindrical wave front at very large distance from source of light



- Point light sources produce spherical wave fronts.
- When a point source is placed at focus of converging lens, plane wave fronts are obtained in laboratory.
- Plane wave fronts reach from the Sun to the Earth, as the earth is far off from the sun.
- The distance between two consecutive wave fronts is one wavelength.
- A line normal to the wave front including the direction of motion is called a ray of light.

Do you know?

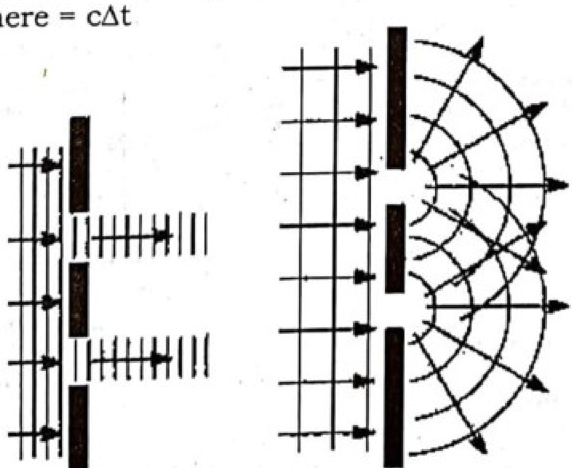
A point source of light placed at principal focus of convex lens will produce a plane wave.

HUYGEN'S PRINCIPLE

(i) Every point on wave front acts as a source of secondary spherical wavelets, which propagate in forward direction with speed of light.

(ii) Position of new wave front is tangent envelope to all of secondary wavelets.

(iii) Radius of hemisphere = $c\Delta t$



- There is an infinite number of secondary wavelets present on wave front.
- Light ray is associated with direction of flow of light energy.

- In a homogeneous medium, the energy of wave is transmitted equal in all sides and wave front remains spherical for long distance

INTERFERENCE OF LIGHT

Interference is a superposition of two light waves of same frequency and same amplitude propagating in same medium along same direction very close to each other.

- For constructive interference, light waves reach a point **in phase** and their path difference $= n\lambda$
- For destructive interference, light waves reach a point in **out of phase** and their path difference = $(2n+1)\frac{\lambda}{2}$

Conditions for interference of light

(i) Monochromatic (Having single wave length)
(ii) Coherence (Having constant phase difference)
(iii) Same direction
(iv) Same medium
(v) Very Close to each other.

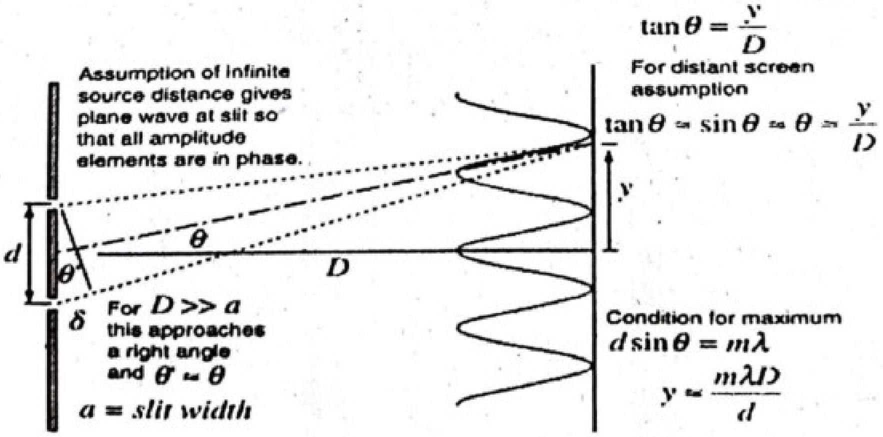
- There is no perfect monochromatic source, but by using filters it is possible to produce a source that gives light whose wavelength differ by $\pm 5\times10^{-10}$ m
- If phase difference between two waves remains constant, then interference pattern will be stationary on screen otherwise it will change continuously.
- *For two ordinary sources, no interference pattern is obtained, because the phase changes rapidly and irregularly* (that's why to get two coherent waves a single beam of light is split into two or more beams).
- *Optical path* is equal to product of refractive index of medium and distance covered in air.

Optical path = nd

where 'n' is refractive index and 'd' is path in air.

YOUNG'S DOUBLE SLIT EXPERIMENT

- Path difference $= d\sin\theta$
- For bright fringes;
  $d\sin\theta = m\lambda$ 1st bright fringe at m = 0
- For dark fringes;
  $d\sin\theta = (2m+1)\frac{\lambda}{2}$ 1st dark fringe at m = 0



- $y_m = \frac{m\lambda D}{d}$ *(position of mth bright fringe)*

- $y_m = (2m+1)\dfrac{\lambda D}{2d}$ *(position of mth dark fringe)*
- $\lambda = y_m \dfrac{d}{mD}$ *(wavelength from bright fringe)*
- $\lambda = 2y_m \dfrac{D}{(2m+1)d}$ *(wavelength from dark fringes)*
- Distance between centers of two consecutive dark fringes or bright fringes is called *fringe width.*

  $F.W = \dfrac{\lambda D}{d}$ (applicable both for bright or dark fringes)

Suggestions to widen the interference fringes

F.W. $\propto \lambda$	(to increase λ)
F.W $\propto$ D	(to increase D)
F.W $\propto 1/d$	(to decrease d)

INTERFERENCE IN DIFFERENT TYPES OF THE FILMS

- Thin film of refracting medium having thickness comparable to the wavelength of light rays e.g.

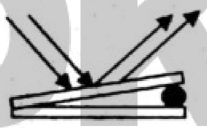
(i) Oil film on water **(ii)** Soap film **(iii)** Air film

- *When exposed to white light*, thin film produces colorful pattern due to interference.
- *When exposed to monochromatic light*, only bright and dark fringes are obtained

Classification of thin films

Uniform or parallel thin films;

Whose thickness is uniform. It gives straight interference pattern.

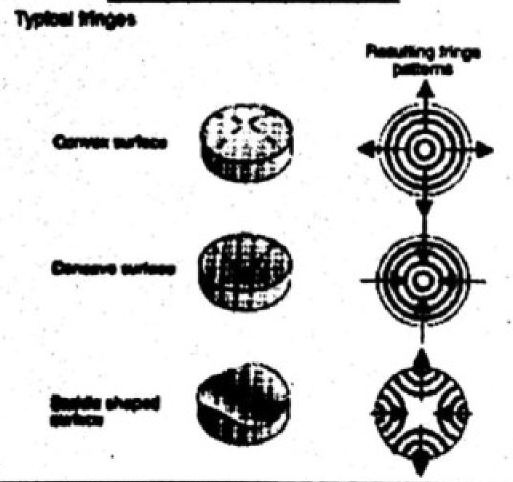


Wedge-shaped films;

Whose thickness is zero at one end and then increases uniformly. *Its interference pattern comprises a set of parallel fringes all parallel to the edge of wedge.*

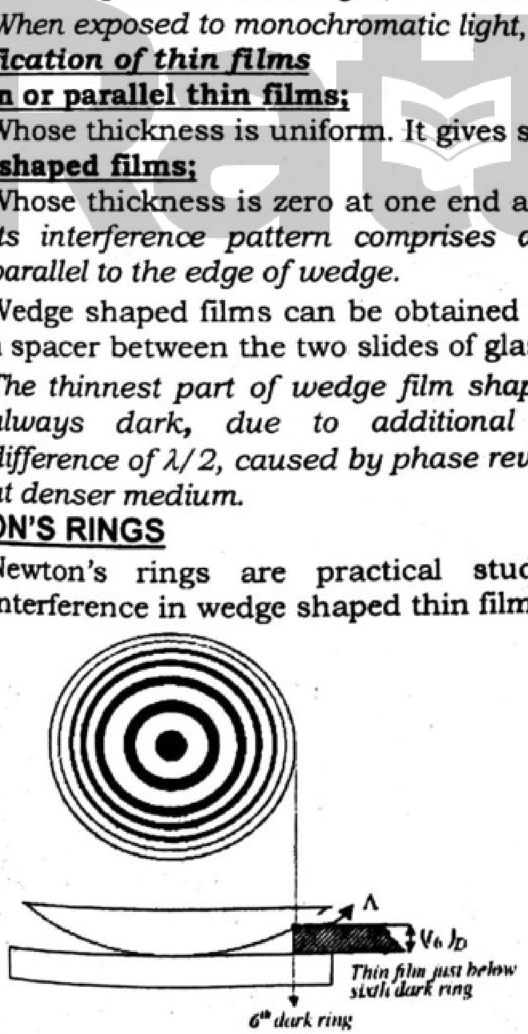
- Wedge shaped films can be obtained using a spacer between the two slides of glass.
- *The thinnest part of wedge film shaped is always dark, due to additional path difference of $\lambda/2$, caused by phase reversal, at denser medium.*

For your information



NEWTON'S RINGS

- Newton's rings are practical study of interference in wedge shaped thin films.



(i) When sodium light is incident on the plano convex lens system, light rays reflect from upper and lower layers of the air present between lens and the glass plate. The sodium light source is almost monochromatic.

(ii) There is no phase change at the lens-air surface, because the wave is going from a higher to a lower refraction index medium. At the air-plate surface, however, there is a phase shift of 180^0 with the reflection from a medium of higher refractive index.

(iii) Waves reflected from these two surfaces interfere, forming bright bands where the path length in air produces two waves in phase and dark bands where the waves are out of phase.

(iv) The centre of the pattern is black.

(v) The fringes are circular as the locus of points of equal thickness of air is a circle.

- Conditions for interference are reversed for Newton's rings as;

Imp

Path difference = $m\lambda$ (for dark ring)

Path difference $=(2m+1)\frac{\lambda}{2}$ (for bright ring)

This is due to **phase reversal by 180°** which is equivalent to an extra path difference of $\frac{\lambda}{2}$.

- Point of contact is always dark due to **phase reversal** at point of contact. Here actual physical path difference is zero.

PRIMARY AND SECONDARY COLOURS

Red, green and blue colours are called *primary* colours. *Complementary* colours of white light are those two colours, whose combined effect is to produce white light on eye. They are;

(i) Red and blue - green

(ii) Yellow and blue - violet

(iii) Green and purple (mixture of red and blue)

If two primary colours *of white light are mixed, we get complementary* colours. e.g. red and green primary colours are mixed, we get yellow, which is complementary colours of blue-violet.

DIFFERENCES BETWEEN LUMINOUS, NON-LUMINOUS AND INCANDESCENT OBJECTS

- A luminous object is one that emits its own light e.g. sun
- A non-luminous object is that which is visible by light it reflects. e.g. moon
- Incandescent object is that which emits light due to heating, e.g. filament of electric bulb.

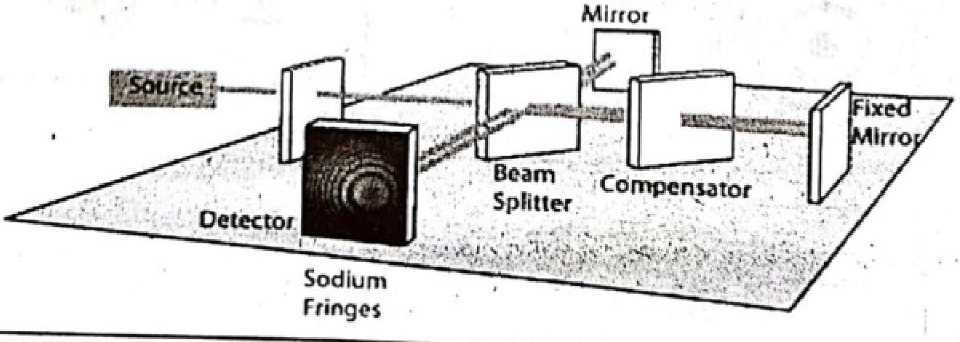
MICHELSON INTERFEROMETER

- Michelson interferometers is an optical instrument used for following purposes;

(i) Testing lenses, mirrors and prisms.

(ii) Measurement of refractive indices.

(iii) Thickness of thin plate through which light can pass.



- *Interferometers are based upon the principle of division of wave front*
- Michelson's interferometer consists of following essential parts;

(i) Diffused source of monochromatic light.
(ii) Beam splitter (semi-silvered glass plate).
(iii) Plane mirrors held ⊥ to each other, one is fixed and the other is movable.
(iv) Micrometer (it is attached to movables mirror)
(v) Compensator (glass plate equal in thickness to beams splitter and of the same material as that of beam splitter).
(vi) Telescope (to observe interference fringes)

- *If mirror is moved by a distance of $\lambda/2$, with* ***dark fringe in view****, then fringe of same kind is observed because* ***total path difference is λ.***
- *If mirror is moved by distance of $\lambda/4$,* ***then alternatively, dark and*** *bright fringes can be observed because* ***total path difference is $\lambda/2$.***
- If mirror is moved through distance p, and 'm' fringes pass before eye.

$$p = \frac{m\lambda}{2}$$

- Interferometer can be used:

(i) To determine refractive index
(ii) To test planes of glass slabs and lenses
(iii) To determine wavelength of light

DIFFRACTION OF LIGHT

Bending of light around sharp edges is called diffraction or the spreading of light waves into geometrical shadow of an obstacle and redistribution of light intensity resulting in dark and bright fringes is called diffraction of light.

- The smaller is the size of diffracting object (obstacle), the higher the degree of diffraction is observed.

Differences between interference and diffraction

INTERFERENCE	DIFFRACTION
(i) Superposition of few secondary wavelets is involved.	**(i) Superposition of large number of secondary wavelets is involved.**
(ii) Interference fringes are equal in size.	**(ii) Diffraction fringes wide near diffracting object and become small as one move away from it.**
(iii) Interference fringes are equally spaced.	**(iii) Diffraction fringes become narrow as distance from diffracting object increases.**
(iv) Points of destructive interference are perfectly dark.	**(iv) Points of minimum intensity are not perfectly dark.**

DIFFRACTION DUE TO NARROW SLIT

- Diffraction due to a narrow slit has central maximum and alternating secondary minima and maxima on its both sides.
- Condition for mth order minima on either side of center is given by

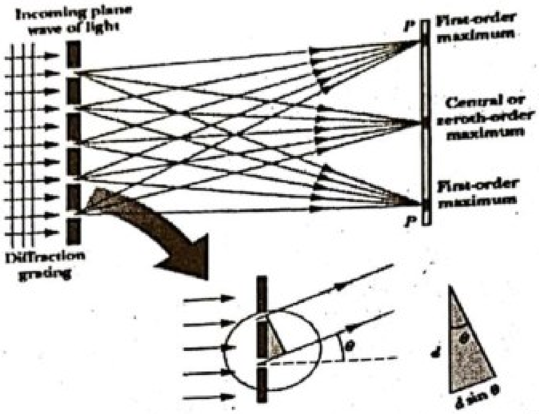
$D \sin\theta = m\lambda$

where $m = 1,2,3,.......$ And D is width of slit.

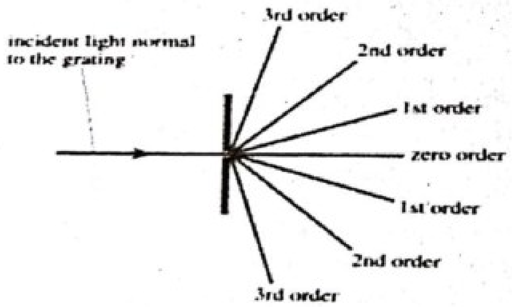
Chapter-9

DIFFRACTION GRATING

Diffraction grating is a multi-slit arrangement of parallel and equally spaced slits. Suppose monochromatic light is directed at the grating parallel to its axis as shown. Let the distance between successive slits be d.



The diffraction pattern on the screen is the result of the combined effects of diffraction and interference. Each slit causes diffraction, and the diffracted beams in turn interfere with one another to produce the pattern. The path difference between waves from any two adjacent slits can be found by dropping a perpendicular line between the parallel waves. By geometry, this path difference is d sin θ . If the path difference equals one wavelength or some integral multiple of a wavelength, waves from all slits will be in phase and a bright line will be observed. Therefore, the condition for maxima in the interference pattern at the angle θ is $\mathbf{d \sin\theta = m\lambda}$
where $\mathbf{n = 0,1,2,3.....}$
Because d is very small for diffraction grating, a beam of monochromatic light passing through a diffraction grating splits into very narrow maxima(bright fringes) at large angles θ.



> **Do you know?**
> Practically a diffraction grating is a piece of glass with 400 → 5000 lines per cm.

- Lines are opaque while separation between them is transparent, so space between two engraved lines behaves as slit.
- Distance between two slits is called *grating element.* $\mathbf{d = 1/N}$
  where 'N' is the number of lines in one unit length.
- Grating equation is given as $\mathbf{d \sin\theta = m\lambda}$
  where 'm' is called the *order of diffraction* pattern.
- For white light, we see colored fringes.

- *Resolving power of grating* is its ability to separate two wavelengths of light in given order of their spectrum.

  Resolving Power = $\lambda/\Delta\lambda = N \times m$

  N = number of lines ruled on grating

  m = order of diffraction

  $\Delta\lambda$ = difference in two wavelengths to be resolved by the grating.

DIFFRACTION OF X-RAYS BY CRYSTALS

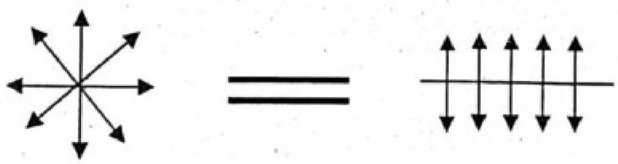
- *Bragg's law* is given as **$2d\sin\theta = m\lambda$**

  Where 'd' is called lattice spacing and θ is called angle of diffraction.
- Solid crystals behave as very good natural diffraction gratings and incident ultraviolet light is diffracted from layers of atoms.
- Inter atomic layer distance is called lattice constant.
- In 1913, Max Von Laue suggested that since atomic layers in solid NaCl have layer separation of **10^{-10} m,** therefore, **X-rays can be diffracted.**
- Max von laue pattern on film is in the form of dark spots/bright spots.
- Analysis of the relative intensity of dark/bright spots gives rise to crystal structure of solid.

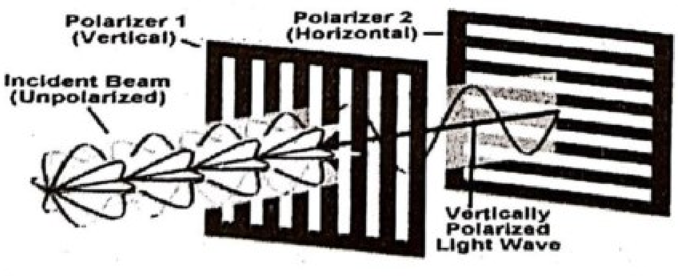
Note: *Diffraction proves that wavelength of light is smaller than that of sound*

POLARIZATION

Confinement of electric vectors of light into one plane is called polarization.



- The material, which produces polarization, is called *polarizor.* e.g. tourmaline crystal is a polarizer.



- *Polariod* (polarizer) absorbs all magnetic vectors as well as randomly oriented electric vectors leaving only those electric vectors, which are in one plane.
- Tourmaline crystal has internal molecular structure such that their interaction with incident light is to;

(i) absorb all magnetic vectors

(ii) put (confine) all electric vector in one plane.

- Polarization is possible only in e.m waves because their electric and magnetic vectors are $\perp$ to each other as well as well to direction of propagation. **Thus, *polarization has established that light is a transverse wave.***
- *Analyzer is used to test plane polarization.*
- Plane determined by direction of propagation and polarized electric vectors of light is called plane of polarization.
- Malus Law : $I = I_0 \cos^2\theta$
- Different methods for producing plane polarized light are given below;

(i) Selective absorption technique (e.g. tourmaline crystal, calcite, crystal)

(ii) Polarization by reflection.

(iii) Polarization by scattering.

<u>Uses of polarized light</u>

(i) Determination of concentration of optically active substance in a solution, e.g. sugar in blood & urine by using polarimeter in medical diagnostic labs.

(ii) Curtainless window.

(iii) To enhance effect of clouds & sky in photograph.

(iv) Headlights of vehicles to control the glare in night driving.

PRACTICE EXERCISE

30 mins Time Yourself

(1) **Optically active crystals rotate the**

(a) vibrating plane (b) polarization plane
(c) diffraction plane (d) interference plane

(2) **Which is not optically active substance?**

(a) sugar (b) tartaric acid
(c) water (d) sodium chlorate

(3) **Huygens' construction can be used only:**

(a) for light (b) for an electromagnetic wave
(c) for all of the above and other situations (d) for transverse waves

(4) **When light incident normally on thin film, the path difference depends upon**

(a) thickness of the film only (b) nature of the film only
(c) angle of incidence only (d) all thickness, nature and angle of incidence

(5) **The reason there are two slits, rather than one, in a Young's experiment is:**

(a one slit is for frequency, the other for wavelength ×
(b) two slits in parallel offer less resistance ×
(c) to increase the intensity ×
(d) to create a path length difference

(6) **Huygen wave theory cannot explain**

(a) diffraction (b) interference
(c) polarization (d) photoelectric effect

(7) **In a Young's double-slit experiment the center of a bright fringe occurs wherever waves from the slits differ in phase by a multiple of:**

(a) $3\pi/4$ (b) π
(c) 2π (d) $\pi/2$

(8) **Light from a small region of an ordinary incandescent bulb is passed through a yellow filter and then serves as the source for a Young's double-slit experiment. Which of the following changes would cause the interference pattern to be more closely spaced?**

(a) Use slits that are closer together × (b) Use a light source of lower intensity ×
(c) Use a blue filter instead of a yellow filter (d) Use a light source of higher intensity ×

(9) **Longitudinal waves do not exhibit**

(a) reflection (b) refraction
(c) diffraction (d) polarization

(10) **In the equation $\sin\theta = \lambda/a$ for single-slit diffraction, θ is:**

(a) the angle to the second maximum (b) the angle to the first minimum
(c) the phase angle between the extreme rays (d) $N\pi$ where N is an integer

(11) **In the equation $d\sin\theta = m\lambda$ for the lines of a diffraction grating m is:**

(a) the slit width × (b) the number of slits ×
(c) the order of the line ✓ (d) the slit separation ×

(12) **The locus of all points in a medium having the same phase of vibration is called**

(a) crest (b) trough
(c) wavelength (d) wave front

(13) **Which one of the following is nearly monochromatic light?**

(a) light from fluorescent tube
(b) light from mercury lamp
(c) light from sodium lamp
(d) light from simple lamp

(14) **Two sources of light are coherent if they emit rays of**

(a) same wavelength
(b) same amplitude of vibration
(c) same wave length with constant phase difference
(d) same amplitude and wavelength

(15) **When crest of one wave falls over the trough of the other wave, this phenomenon is known as**

(a) polarization
(b) constructive interference
(c) destructive interference
(d) diffraction

(16) **In Young's double slit experiment, the fringe spacing is equal to (d= slit separation and D = distance of screen from slits)**

(a) $d\lambda D$
(b) $2\lambda d/D$
(c) $\lambda D/d$
(d) $\lambda d/D$

7:32
7 min

(17) **Under which of the following sets of conditions will the separation of the bright fringes of a double-slit interference pattern be greatest?**

	Distance between slits	Distance from slits to screen	Wavelength of source
(a)	Small	Small	Short
(b)	Small	Large	Long
(c)	Small	Large	short
(d)	Large	Small	Short

(18) **Two monochromatic radiations X and Y are incident normally on a diffraction grating. The second order intensity maximum for X coincides with the third order intensity maximum for Y.**

What is the ratio $\dfrac{\text{wavelength of X}}{\text{wavelength of Y}}$?

$\lambda \propto \frac{1}{m}$

(a) $\dfrac{1}{2}$
(b) $\dfrac{3}{2}$
(c) $\dfrac{2}{3}$
(d) $\dfrac{2}{1}$

(19) **The condition for constructive interference of two coherent beams is that the path difference should be**

(a) integral multiple of $\lambda/2$
(b) integral multiple of λ
(c) odd integral multiple of $\lambda/2$
(d) even integral multiple of λ

(20) **In an interference pattern**

(a) bright fringes are wider than dark fringes
(b) dark fringes are wider than bright fringe
(c) both dark and bright fringes are of equal width
(d) central fringes are dimmer than the outer fringes

(21) **In Young's double slit experiment, the separation between the slit is halved and distance between the slit and screen is doubled. The fringe width is**

(a) remain same
(b) double
(c) half
(d) quadrupled

(22) **The blue colour of the sky is due to**
(a) diffraction (b) reflection
(c) polarization (d) scattering

(23) **A light ray traveling from denser to rarer medium suffers a phase change of**
(a) 0^o (b) 90^o
(c) 180^o (d) 45^o

(24) **When one mirror of a Michelson Interferometer is moved a distance of 0.5 mm, we observe 2000 fringes. What will be wavelength of light used?**
(a) 5000 nm (b) 5000 A^o
(c) 500m (d) 2000μm

(25) **Diffraction effect is**
(a) more for a round edge (b) less for a round edge
(c) more for a sharp edge (d) less for a sharp edge.

1:50

(26) **The wavelength of X- rays is of the order of**
(a) $10A^o$ (b) $1000 A^o$
(c) $1A^o$ (d) $100 A^o$

(27) **Wavelength of X- rays falling at glancing angle of 30^o on a crystal with atomic spacing $2x10^{-10}$m for the fist order diffraction is**
(a) $4x10^{-10}$m (b) $2x10^{-10}$m
(c) $0.02x10^{-10}$m (d) $20x10^{-10}$m

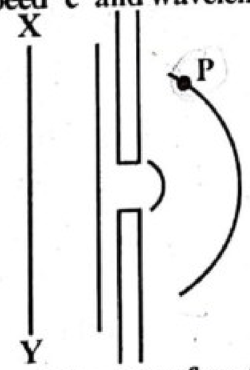
(28) **A diffraction grating has 500 lines per mm. Its slit spacing or grating element will be equal to**
(a) 500 mm (b) $5x10^{-3}$ mm
(c) $2x10^{-5}$ mm (d) $2x10^{-3}$mm

(29) **In a plane polarized light electric vibration are**
(a) in all direction
(b) in two mutually perpendicular directions
(c) taking place perpendicular to the direction of propagation of light
(d) no vibration at all.

(30) **Light on passing through a Polaroid is**
(a) plane polarized (b) un-polarized
(c) circularly polarized (d) elliptically polarized

(31) **Which one of the following cannot be polarized?**
(a) radio waves (b) ultraviolet rays
(c) X-rays (d) ultrasonic waves

(32) **A monochromatic plane wave of speed 'c' and wavelength λ is diffracted at a small aperture.**



The time during which a portion of the wavefront XY reaches at 'P' will be
(a) $\frac{3\lambda}{2C}$ (b) $\frac{2\lambda}{C}$
(c) $\frac{3\lambda}{C}$ (d)) $\frac{4\lambda}{C}$

(33) In monochromatic red light, a blue book will probably appear to be

(a) black
(b) purple
(c) green
(d) no scientific reasoning available

(34) A polarizer is used to

(a) Reduce the intensity of light
(b) produce polarized light
(c) increase intensity of light
(d) both a and b

(35) In double slit experiment, if one of the two slit is covered then

(a) no interference fringes are observed
(b) no diffraction fringes are observed
(c) no fringes observed
(d) interference pattern not disturbed

(36) ____________ gives the definition of metre in terms of wavelength of red cadmium light

(a) Newton
(b) Einstein
(c) Michelson
(d) Galileo

(37) In Michelson interferometer to switch the fringe from bright to dark the mirror should be displaced through

(a) λ
(b) $\lambda/3$
(c) $\lambda/6$
(d) $\lambda/4$

(38) In the shadow of a ball the central portion appears bright that happens due to

(a) Interference
(b) Diffraction
(c) Polarization
(d) Refraction

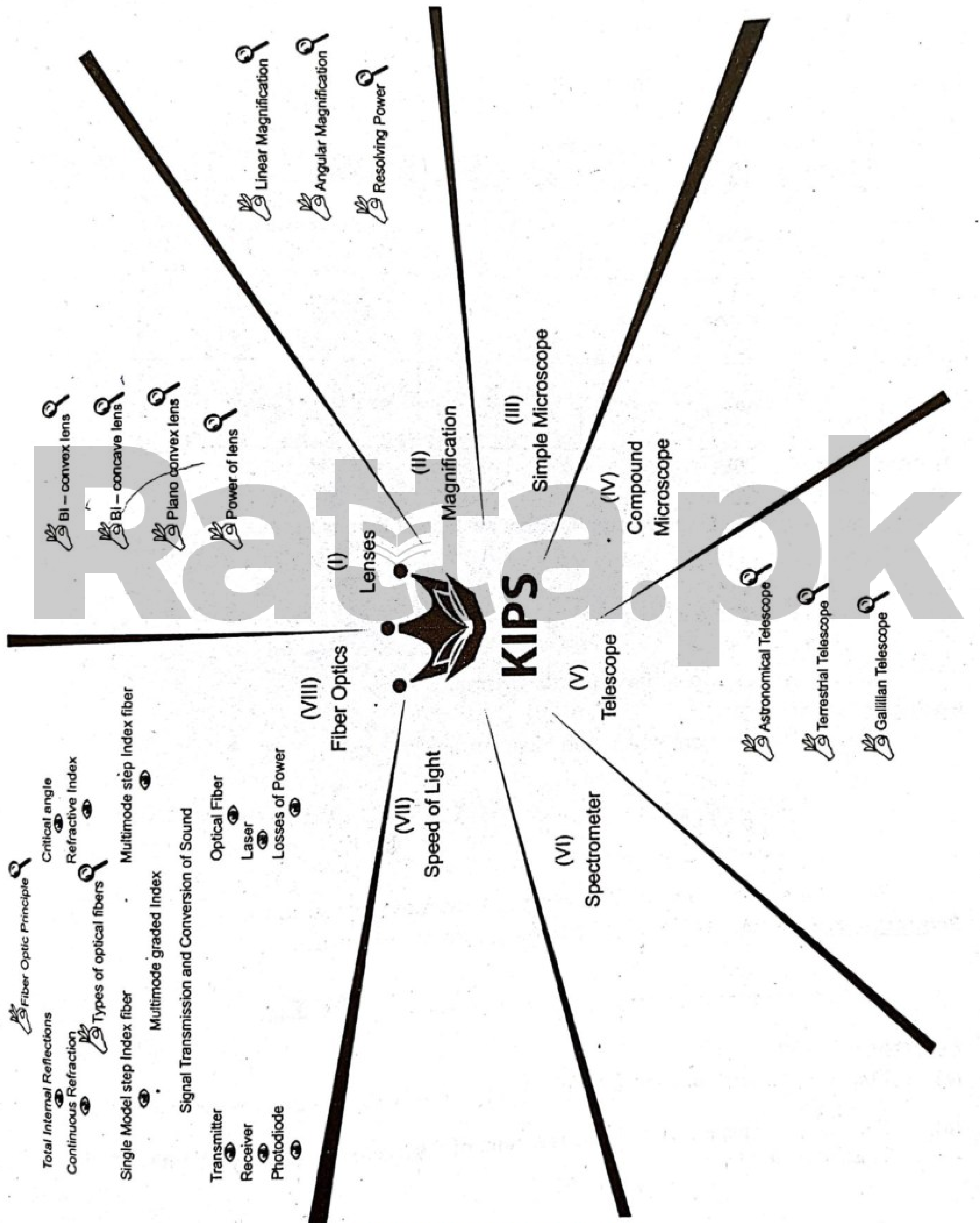
(39) Which experiment shows that wavelength of light is smaller than that of sound

(a) Diffraction
(b) Polarization
(c) Interference
(d) Reflection

(40) Crystals of a material can behave as

(a) Convex lens
(b) Interferometer
(c) Diffraction grating
(d) Concave

Chapter 10 OPTICAL INSTRUMENTS



LENS

- Lens is a piece of transparent medium bounded by two surfaces at least one of which is curved.
- Every lens is a part of some sphere.

Types of Lenses

Convex lens: It is thicker at the middle and thinner at the edges.

Concave lens: It is thinner at the middle and thicker at the edges.

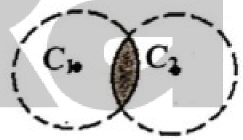
Types of Convex and Concave Lenses

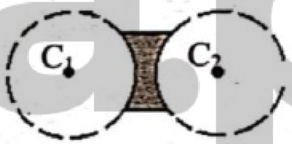
SR #	CONVEX LENS		CONCAVE LENS	
1	Double convex		Double concave	
2	Plano convex		Plano concave	
3	Concavo convex		Convexo concave	

Important Definitions

Centre of curvatures:

Centre of sphere from which spherical surface of lens is obtained.

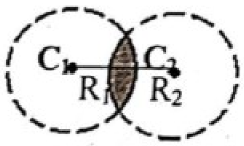


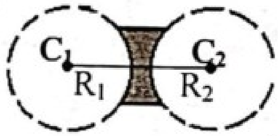


Every lens has two centers of curvatures.

Radius of curvature:

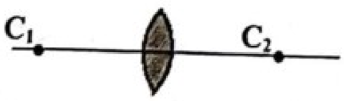
Radius of sphere from which spherical surface of lens is obtained.

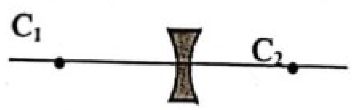




Every lens has two radii of curvature that may not be equal.

Principal axis is the line joining its two centers of curvature.

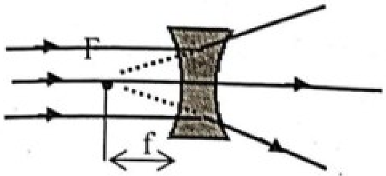


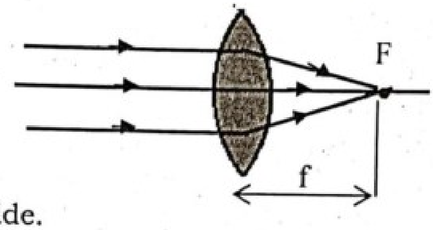


Principal focus:

(a) For convex lens, principle focus is a point of convergence of refracted light ray. It is a real point.

(b) For concave lens, principal focus is a point of divergence of refracted light rays. It is imaginary point.





Every lens has two foci one on each side.

Optical centre is a point inside the body of lens through which light rays pass, undeviated.

Focal length is a distance between principal focus and optical center. It is positive for convex lens and negative for concave lens.

Note: *It is not necessary that two focal lengths are equal for a lens.*

Aperture is the size of diameter of lens.

Power of a lens is its ability to deviate light ray from its original path.

$P = 1/f$

where 'f' is focal length in meter.

If 'f' is in cm, then-

$P = 100/f$

- SI unit of power of lens is dioptre.

$P = 1D$ if $f = 1m$

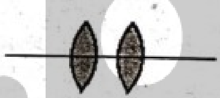
General rule for combination of 'n' lenses

General rule for combination of 'n' lenses is

$P = P_1 + P_1 + \text{-----------} + P_n$

Examples

For two double convex lenses;



$$P = P_1 + P_2$$

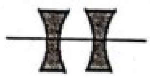
$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{f} = \frac{f_1 + f_2}{f_1 f_2}$$

$$f = \frac{f_1 f_2}{f_1 + f_2}$$

Thus combination behaves as a convex lens.

For two concave lenses;



$$P = P_1 + P_2$$

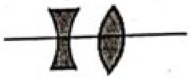
$$\frac{1}{f} = -\frac{1}{f_1} - \frac{1}{f_2}$$

$$\frac{1}{f} = \frac{-(f_1 + f_2)}{f_1 f_2}$$

$$\frac{1}{f} = \frac{-f_1 f}{f_1 + f_2}$$

Thus combination behaves as a concave lens.

For one convex and other concave lens;



$$P = P_1 + P_2$$

$$\frac{1}{f} = \frac{1}{f_1} - \frac{1}{f_2}$$

$$\frac{1}{f} = \frac{f_2 - f_1}{f_1 f_2}$$

$$f = \frac{f_1 f_2}{f_2 - f_1}$$

Thus combination may behave as a convex or concave lens.

Lens Formula

- General lens formula is given as;

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

p is +ve for real object and -ve for virtual object.
q is +ve for real image and -ve for virtual image.
f is +ve for convex lens and -ve
for concave lens.

- For different cases, we have to modify it.

Examples

For a virtual object;

$$\frac{1}{p} + \frac{1}{-q} = \frac{1}{f}$$

For concave lens;

$$\frac{1}{p} + \frac{1}{-q} = -\frac{1}{f}$$

Do you know?

Positive sign is used where rays actually intersect. If not then we can use negative sign

Position and Nature of Image for Convex Lens

Position of object	Position of image	Nature of image
Beyond 2F	*Between F and 2F*	*Real, inverted, small*
At 2F	*At 2F*	*Real, inverted, equal*
Between F and 2F	*Beyond 2F*	*Real, inverted, enlarged*
At F	*At infinity*	*Real, inverted, enlarged*
Inside F	*On same side further away from lens than the object*	*Virtual, erect, enlarged*

Magnification of a Lens

- Linear magnification is given as;

$$M = \frac{q}{p} = \frac{h_i}{h_o} = \frac{\text{size of image}}{\text{size of object}}$$

- Angular magnification is given as;

$$M = \frac{q_i}{q_o} = \frac{\text{Angle formed at aided eye}}{\text{Angle formed at naked eye}}$$

- For real image;

$$M = \frac{q}{p}$$

- For virtual image;

$$M = \frac{-q}{p}$$

Do you know?

For very small angles we can equate linear and angular magnifications.

Visual Angle

- Visual angle is angle made by object at observer's eye.
- Apparent size of object varies with visual angle.
- Apparent size $\propto$ visual angle

Resolving Power

The resolving power of an instrument is its ability to reveal the minor details of the object under examination.

Angle of Resolution

The minimum angle that allows two point sources to appear distinctly separated is called angle of resolution. It is expressed as α_{min} , $\alpha_{min} = 1.22\dfrac{\lambda}{D}$

Raleigh showed that resolving power of a lens of aperture D, under a light source of wavelength λ is. $R = \dfrac{D}{1.22\lambda}$

Lens Aberrations

Spherical aberration

It is the formation of blurred image due to size of lens because outer rays undergo more refraction than the inner ones.

Chromatic Aberration

It is the inability of a lens to bring all light rays (all colours) at single focus. Multicoloured blurred image is formed.

Remedy

Provide such constraints on the lens that allows only paraxial rays to enter the lens.

Remedy

Use the combination of convex and concave lenses called as achromatic lenses.

LEAST DISTANCE OF DISTINCT VISION

It is the minimum distance at which a normal eye can see an object clearly. d = 25cm

> **Do you know?**
> As we get over the years upto old age the value of least distance of distinct vision is drastically affected.

OPTICAL INSTRUMENTS

Optical instruments are those, which use light for their operations e.g.

(i) Simple microscope (ii) Compound microscope (iii) Telescope
(iv) Camera (v) Michelson interferometer (vi) Spectrometer
(vii) Periscope

SIMPLE MICROSCOPE

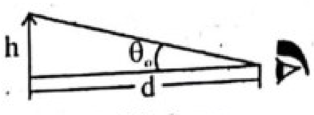
Simple microscope(magnifier) is a double convex lens of short focal length. ⇒ Its magnifying power is;

$$M = 1 + \frac{d}{f}$$

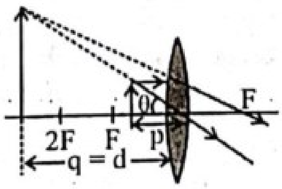
d = 25 cm
f = focal length.

✦ It forms virtual, erect and magnified image at d.

$$M \propto \frac{1}{f}$$



Unaided-eye



COMPOUND MICROSCOPE

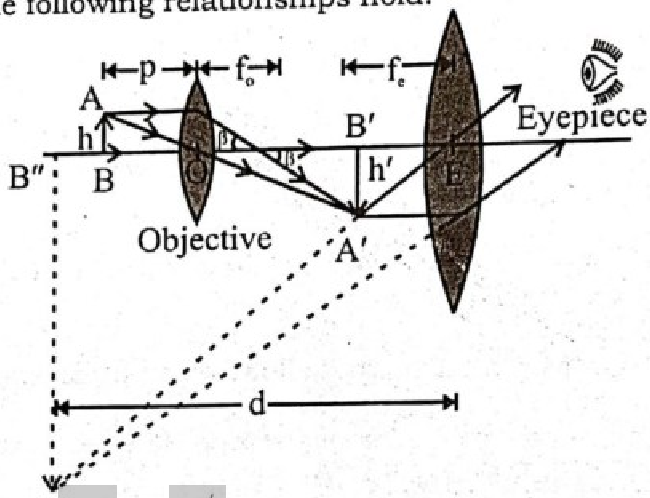
Compound microscope consists of two convex lenses.

(a) **Objective lens** of small size and short focal length.

(b) **Eyepiece lens** of large size and large focal length.

A compound microscope uses a very short focal length objective lens to form a greatly enlarged image. This image is then viewed with a short focal length eyepiece used as a simple magnifier.

The general assumption is that the length of the tube L is large compared to either f_o or f_e so that the following relationships hold.



$$M = \frac{L}{f_o}\left(1 + \frac{d}{f_e}\right)$$ where L is the distance between two lenses (eyepiece and objective).

Do you know?

A wider objective and use of blue light of short wavelength produces less diffraction and allows more details to be seen

Note:

(a) $f_o < f_e$ *always* otherwise it will becomes astronomical telescope.

(b) In case of expensive microscopes, eye-piece and objectives are combination of lenses to reduce lens defects.

(i) Objective forms real image while eyepiece forms virtual image.

(ii) *Magnification of objective* = $\frac{L}{f_o}$

(iii) *Magnification of eyepiece* = $1 + \frac{d}{f_e}$

TELESCOPE

Telescope is an optical instrument, which enables the observer to see fine details of a far off object.

- Two major classes of telescopes are given below:

(i) Reflecting telescopes

(ii) Refracting telescopes
- Astronomical
- Galilean
- Terrestrial

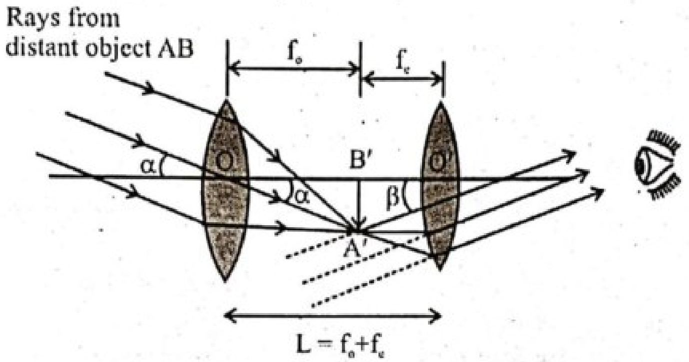
ASTRONOMICAL TELESCOPE

- It is used to see images of heavenly bodies.
- It consists of two lenses.

(a) **Objective** is double convex lens of large focal length and large aperture.

(b) **Eyepiece** is a double convex lens of short focal length and small aperture.

✦ When set for infinity or parallel rays, then; $\mathbf{L = f_o + f_e}$



Advantages:

(i) High magnifying power

$$M = \frac{f_o}{f_e}$$

(ii) Large field of view.

Disadvantages:

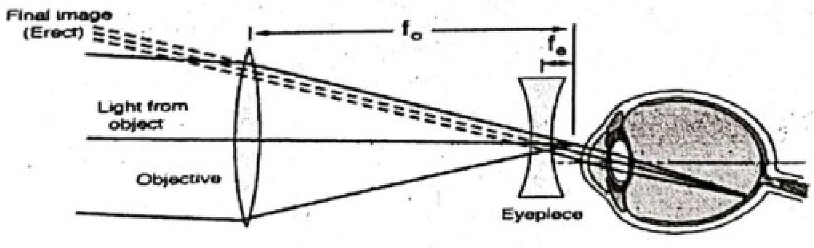
Final image is inverted.

Do you know?

A good telescope has an objective of long focal length and large aperture.

GALILEAN TELESCOPE

The Galilean or terrestrial telescope uses a positive objective and a negative eyepiece. It gives erect images and is shorter than the astronomical telescope with the same power. It's angular magnification is $-\frac{f_o}{f_e}$.



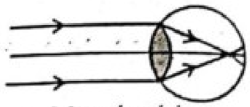
Defects Of Vision:

In case of eye following are the common defects of vision:

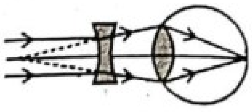
- Myopia (or short-sightedness or Near-sightedness)
- Hyperopia (also known as hypermetropia or longsightedness or Far-sightedness).
- Presbyopia
- Astigmatism

Chapter-10

Myopia (Or Short-Sightedness Or Near-Sightedness):



Myopic vision

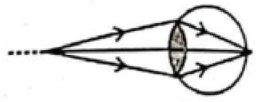


Corrected vision

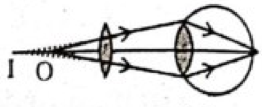
Cause: In it distant objects are not clearly visible, i.e., far point is at a distance lesser than infinity and hence image of distant object is formed before the retina.

Remedy: This defect is remedied by using spectacles having divergent lens (i.e., negative focal length or power) which forms the image of distant object at the far point of patient (which is lesser than ∞).

Hyperopia (Long Sightedness Or Far-Sightedness):



Hypermetropic vision



Corrected vision

Cause: In it near objects are not clearly visible, i.e., near point is at a distance greater than 25 cm. image of near object is formed behind the retina.

Remedy: This defect is remedied by using spectacles having convergent lens (i.e., positive focal length or power) which forms the image of near objects at the near point of the patient eye (which is more than 25 cm).

Presbyopia:

Cause: In this both near and far objects are not clearly visible, i.e., far point is at a distance lesser than infinity and near point at a distance greater than 25 cm. it is an old age disease as in old age ciliary muscles lose their elasticity and so cannot change the focal length of eye-lens effectively and hence eye loses its power of accommodation.

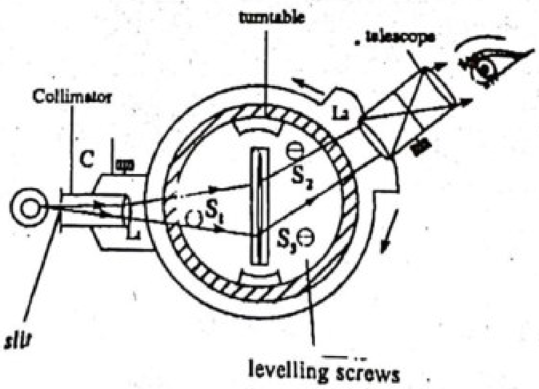
Remedy: This is remedied either by using two separate spectacles one for myopia and the other for hypermetropia or using single spectacle having bifocal lenses.

SPECTROMETER

It is an optical instrument used to study spectrum of light.

- It has following parts: -

(i) **Collimator:** It has slit at focus of a double convex lens to get a parallel beam of light.
(ii) **Telescope:** It is an astronomical telescope.
(iii) **Turn table:** Prism or diffraction grating is placed on table called turn table.
(iv) **Leveling screws**



Working

(i) Telescope is set for infinity and fixed.
(ii) Source of monochromatic light is placed in front of slit and collimator is adjusted for parallel rays.
(iii) Angle of minimum deviation (D_m) is experimentally determined.
Then refractive index of prism is given as;

$$m = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Where 'A' is angle of prism or apex angle.

(iv) For wavelength of monochromatic light diffraction grating is used.

$d \sin \theta = m\lambda$

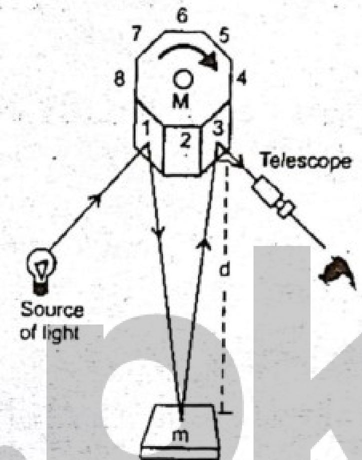
$$\lambda = \frac{d \sin\theta}{m}$$

Usually m = 1 (first order diffraction),

d = grating element

$d = \frac{1}{N}$ where N is the number of rulings per centimeter

SPEED OF LIGHT



- First attempt to measure the speed of light was made **by Galileo**
- First time speed of light measured accurately by Michelson
- The Michelson's formula for determination of speed of light is ***c =16 f d***
  where f is frequency of rotation of octagonal mirror and d is distance between plane mirror and octagonal mirror.

INTRODUCTION TO FIBRE OPTICS

- *Graham Bell invented* **photo phone to** transmit voice massage via beam of light.
- In optical fiber, light is used as a **transmission carrier wave.**
- *The principle of transmitting signals through optical fibre is*

(i) *Total internal reflection*

(ii) *Continuous refraction*

- *Optical fibre* is a fine glass rod having diameter in the range of micrometers

CLASSIFICATION OF OPTICAL FIBRES

Single mode step index fibre

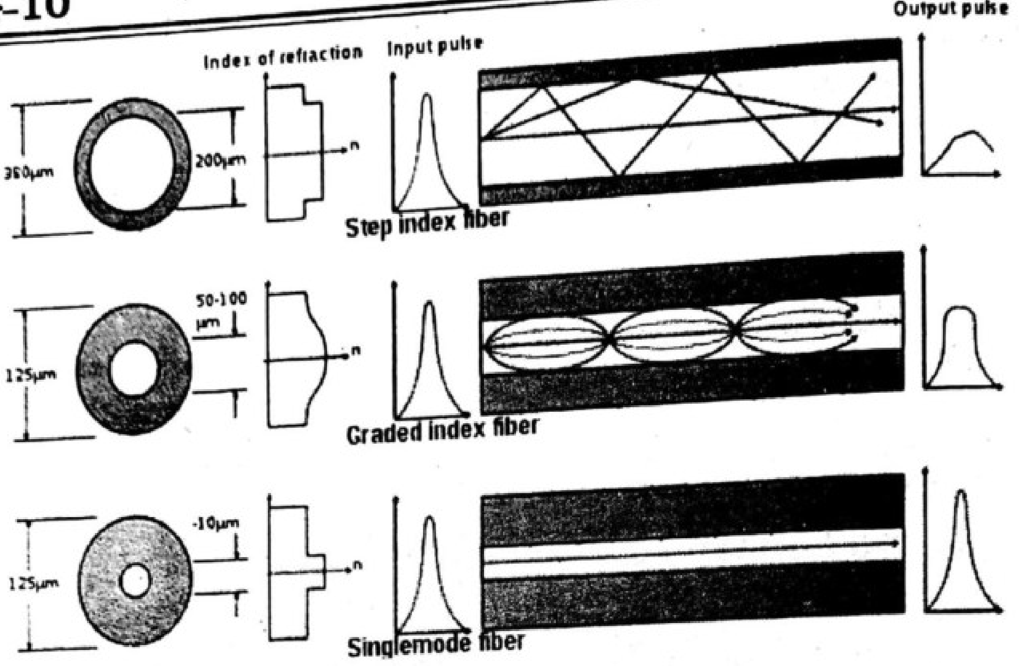
It is also called mono mode fibre & has very **narrow** core of diameter about 5 μm.

Multimode step index fibre

It has larger core (50μm) of constant refractive index. Refractive index change at the boundary of core and cladding. It is useful for a short distance only. The mode of transmission in it is total internal reflection.

Multimode graded index fibre

In it, core has diameter from 50 to 1000 μm. There is no noticeable boundary between core and cladding. mode of transmission of light in it is continuous refraction. It is suitable for l tance transmission in which white light is used.



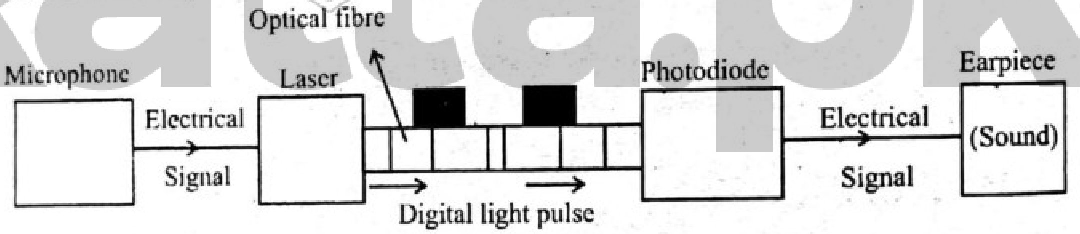
SIGNAL COMMUNICATION

- Fibre optic communication system consists of three parts

(i) ***Transmitter:*** To convert electrical signals to light signals

(ii) ***Optical Fibre:*** To guide the light signals

(iii) ***Receiver:*** To capture the light signal and convert them to electric signals.



- Light signals travel through fibre in `on` and `off` fashion called digital modulation. A light pulse **represents, 1 and** absence of light **represents 'O'**

<u>Advantages of communication through optical fibre</u>

(i) Light signals in glass travel faster than electrical signals in copper cable

(ii) More massages per cable length. (High signal strength)

(iii) Clear sound is received

LOSSES OF POWER

- Power is lost in optical fibre due to scattering of light from impurity atoms in glass
- Due to dispersion of light, signal also get weak.
- Power loss in signal due to dispersion can be reduced by using graded index fibre.
- *Repeaters* are used at suitable distance to overcome the power loss due to scattering from impurity atoms.

PRACTICE EXERCISE

30 mins Time Yourself

(1) **The resolving power of a telescope can be increased by:**
(a) increasing the objective focal length and decreasing the eyepiece focal length
(b) increasing the lens diameters
(c) decreasing the lens diameters
(d) inserting a correction lens between objective and eyepiece

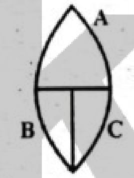
(2) **A point where the incident parallel rays of light converge or appear to diverge after passing through a lens is called**
(a) center of curvature
(b) focus
(c) optical center
(d) aperture

(3) **Who invented photo phone?**
(a) Graham Bell
(b) Galileo
(c) Torricelli
(d) Maxwell

(4) **Resolving power of microscope is proportional to**
(a) λ
(b) $\frac{1}{\lambda}$
(c) λ^2
(d) $\frac{1}{\lambda^2}$

(5) **Typical fibre optic communication system uses light of which wavelength**
(a) 1.3μm
(b) 1.3 nm
(c) 13μm
(d) 13 nm

(6) **A thin symmetric double convex lens of power P is cut into three parts A,B and C as shown the power of**



(a) A is P/2
(b) A is 2P
(c) C is P
(d) B is P/2

(7) **If a lens is covered with wax then**
(a) Intensity become double
(b) Image will not formed
(c) Intensity will remain same
(d) Intensity will become half

(8) **The minimum distance between an object and its real image in a convex lens is**
(a) 2 f
(b) 2.5 f
(c) 3f
(d) 4f

(9) **If an object is placed away from '2f' of a converging lens, then the image will be**
(a) real and erect
(b) virtual and erect
(c) real and inverted
(d) virtual

(10) **If the length of telescope is 96cm the focal lengths of its lenses is**
(a) 100cm , - 4cm
(b) -80cm , -6cm ×
(c) 90cm , -6cm ×
(d) 90cm , 6cm

(11) **Magnifying power of simple microscope**
(a) increase with increase in focal length
(b) increase with decrease in focal length
(c) no effect with decrease or increase with focal length
(d) least distance of distinct vision

(12) **The magnifying power of a compound microscope increases when:**
A) The focal length of objective lens is increased and that of eye lens is decreased
B) Focal lengths of both objective and eye-piece are increased
C) The focal length of eye lens is increased and that of objective lens is decreased
D) Focal lengths of both objective and eye-piece are decreased

(13) **The speed of light in the medium of refractive index of 1.5 is**
(a) $2 \times 10^8 ms^{-1}$ (b) $3 \times 10^8 ms^{-1}$
(c) $0.5 \times 10^8 ms^{-1}$ (d) $1.5 \times 10^8 ms^{-1}$

(14) **Least distance of distinct vision for normal and healthy people**
(a) increases with increase in age (b) decreases with increase in age
(c) neither increases nor decreases (d) becomes infinite after 60 years

(15) **If a convex lens of large aperture fails to converge the light rays incident on it to a single point, it is said to suffer from**
(a) chromatic aberration (b) spherical aberration
(c) both spherical and chromatic (d) distortion

(16) **Two convex lenses of equal focal length 'f ' are placed in contact, the resultant focal length of the combination is**
(a) zero (b) f
(c) 2 f (d) $\frac{f}{2}$

(17) **A convex lens of focal length 'f_1' and a concave lens of focal length 'f_2' are placed in contact. The focal length of the combination is**
(a) $f_2 + f_1$ (b) $f_2 - f_1$
(c) $\frac{f_1 f_2}{f_2 + f_1}$ (d) $\frac{-f_1 f_2}{f_1 - f_2}$

(18) **Final image produced by a compound microscope with respect to the object is**
(a) real and inverted (b) real and erect
(c) virtual and erect (d) virtual and inverted

(19) **For normal adjustment, length of astronomical telescope is**
(a) $f_o + f_e$ (b) $f_o - f_e$
(c) $\frac{f_o}{f_e}$ (d) $\frac{f_e}{f_o}$

(20) **A surf board moves at a speed of $5ms^{-1}$ on the crests of a wave. The distance between wave crests is 10m. what is the frequency of the wave motion**
(a) 2 Hz (b) 5Hz
(c) 10Hz (d) 0.5Hz

(21) **Dispersional effect may produce error in light signals. This type of error is minimum in**
(a) single mode step index fibre (b) multimode step index fibre
(c) multimode graded index fibre (d) monomode step index fiber

(22) **Light signals pass through multimode graded index fibre due to**
(a) continuous refraction
(b) total internal reflection
(c) both continuous refraction and total internal reflection
(d) diffraction

(23) **Which one type of fibre is more suitable for transmission of signals in which white light is used?**
(a) mono mode step index fibre (b) multi mode step index fibre
(c) multi mode graded index fibre (d) single mode step index fibre

(24) **Critical angle is that incident angle in denser medium for which angle of refraction is**
(a) 0° (b) 45°
(c) 90° (d) 180°

(25) **There is no noticeable boundary between core and cladding for**

(a) multi mode step index fibre
(b) multi mode graded index fibre
(c) single mode step index fibre
(d) all types of fibre

(26) **The electrical signals change into light signals for transmission through optical fibre. A light pulse represent**

(a) zero (0)
(b) one (1)
(c) both zero (0) and one (1)
(d) either zero (0) or one (1)

(27) **A lens, which is thicker at the center and thinner at the edges, is called**

(a) concave lens
(b) convex lens
(c) plano convex lens
(d) plano concave lens

(28) **A spectrometer is used to find**

(a) wave length of light
(b) refractive index of the prism
(c) wavelength of different colours
(d) all of the above

(29) **If a convex lens of focal length 'f' is cut into two identical halves along the lens diameter, the focal length of each half is**

(a) f
(b) f/2
(c) 2f
(d) 3f/2

(30) **A convex and concave lens of focal length 'f' are in contact, the focal length of the combination will be**

(a) zero
(b) f/2
(c) 2f
(d) infinite

$\frac{f_1f_2}{f_2-f_1}$ $f_2=f_1$ $\frac{f_1^2}{f_1-f_1}=\frac{f_1^2}{0}=\infty$

(31) **If the red light is replaced by blue light illuminating the object in a microscope the resolving power of the microscope**

(a) increases
(b) decreases
(c) remain same
(d) become half

(32) **In optic fiber transmission system ____________ are used to regenerate the dim light signal.**

(a) Diodes
(b) Repeaters
(c) Laser
(d) Transformer

(33) **Magnification of the astronomical telescope is**

(a) f_o+f_e
(b) $\frac{f_o}{f_e}$
(c) $\frac{f_e}{f_o}$
(d) $\left(1+\frac{f_o}{f_e}\right)\frac{L}{f_o}$

(34) **The equation $\alpha_{min} = 1.22\ \lambda/D$ was devised by**

(a) Newton (b) Einstein

(c) Raleigh (d) Planks

(35) **The central image in compound microscope is**

(a) virtual, erect and magnified (b) real, inverted and larger than object

(c) virtual, erected and magnified (d) erect, virtual and smaller than final image

(36) **Michelson calculated the speed of light using the instrument**

(a) spectrometer (b) galvanometer

(c) interferometer (d) none of these

(37) **Michelson devised the formula to calculate the speed of light**

(a) $c = 4fd$ (b) $c = 8fd$

(c) $c = 16fd$ (d) $c = \frac{5}{2}fd$

(38) **The function of collimator in spectrometer is**

(a) to produce parallel beam of light (b) to filter the ligh

(c) to make them mutually perpendicular (d) no function

(39) **In optic fiber transmission the repeaters are separated through a distance of ________________ km in newer system.**

(a) 300km (b) 200km

(c) 100km (d) 20km

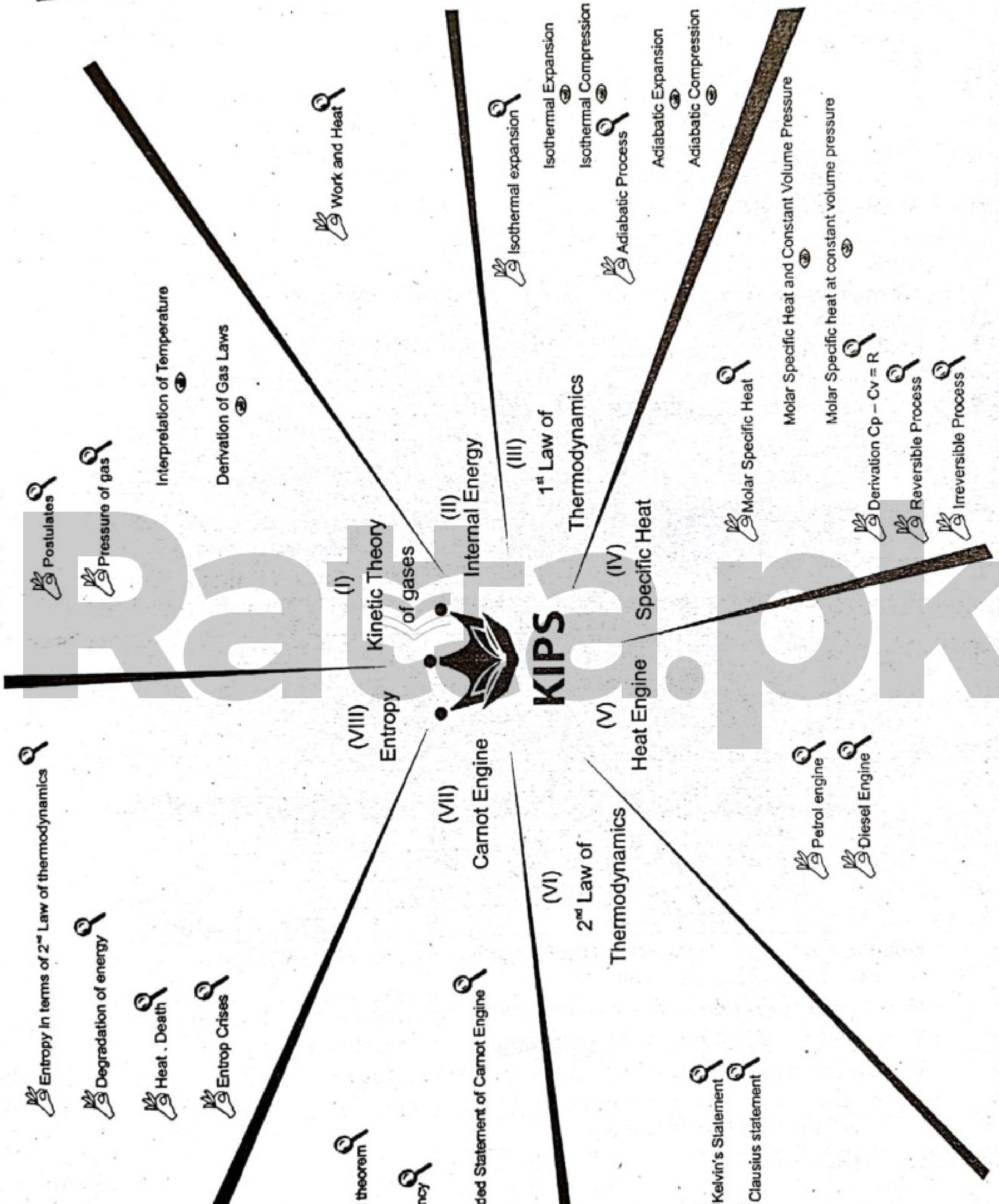
(40) **Which colour has the maximum angle of deviation in prism**

(a) red (b) blue

(c) orange (d) green

Chapter 11

HEAT AND THERMODYNAMICS



INTRODUCTION

- *Heat* is a form of energy that is in transit.
- *Temperature* is a measure of degree of hotness or coldness of a body.
- Change of temperature affects the physical state of matter.

Effects of temperature

(i) Change of colour
(ii) Change of state
(iii) Change of resistance.

Do you know?
Celsius degree is larger than a Fahrenheit degree by a factor of 9/5.

Major types of thermometer

(i) Mercury glass thermometer
(ii) Bimetallic thermometer

- Any substance that changes uniformly with temperature can be used as *thermometric substance* in thermometer.
- *Mercury is preferred as thermometric substance* because-

(1) It is non-wetting
(2) Its expansion is quite linear
(3) Boiling point is high.

Conversion formulas of temperature scales

(i) $T_C = \frac{5}{9}(T_F - 32)$

(ii) $T_F = \frac{9}{5}T_C + 32$

(iii) $T_K = 273 + T_C$

(iv) $T_K = 273 + \frac{5}{9}(T_F - 32)$

(v) $T_C = T_K - 273$

(vi) $T_F = \frac{9}{5}(T_K - 273) + 32$

Do you know?
The centigrade and Fahrenheit scale shows the same reading at a temperature of -40°.

Important Temperature Conversions

DESCRIPTION	K	C°	F°
Boiling point of water	373	100	212
Freezing point of water	273	0	32
Normal body temperature	310	37	98.6
Absolute zero	0	– 273	–460

- *Absolute zero* is a temperature at which if gases remain in gaseous form, exert zero pressure and have zero volume.
- Heat flows from one body to another due to temperature difference.
- Temperature determines the direction of natural flow of heat.
- Internal energy or thermal energy is the sum of K.E and PE of all molecules of a body.
- When excess of thermal energy flows from one body to another, as heat, then it is converted into internal energy.

KINETIC MOLECULAR THEORY OF GASES (K.M.T)

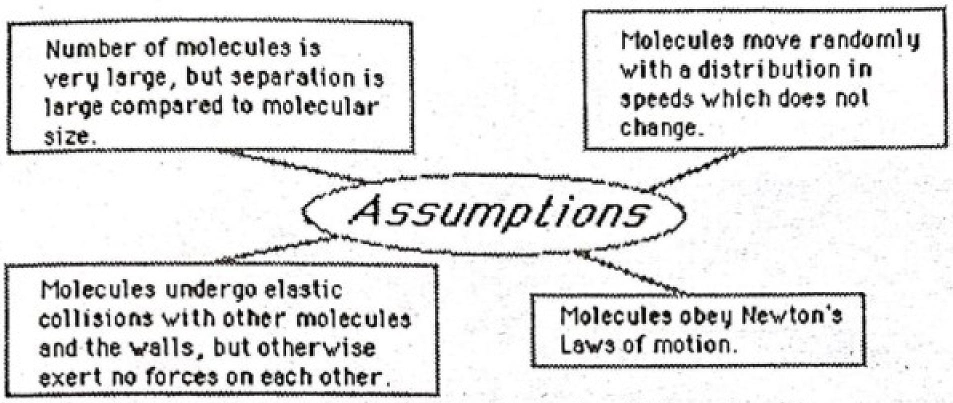
Main points of K.M.T of gases are given as:

(i) Small volume contains large number of molecules.
(ii) Molecules move randomly and do not exert force on one another except when they collide.
(iii) Molecules collide each other elastically.
(iv) The collisions with 'walls' give rise to gas pressure.

(v) Gravity does not affect the molecular motion.
(vi) Volume of gas molecules is negligible as compared to the actual volume of the gas.

PRESSURE AND TEMPERATURE OF AN IDEAL GAS

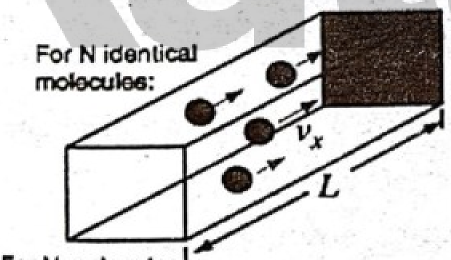
The kinetic theory of gases is the study of the microscopic behavior of molecules and the interactions which lead to macroscopic relationships like the ideal gas law.



Developments will be made with collections of identical molecules, but the results can be generalized.

Newton's Laws and Collisions:

Applying Newton's law to an ideal gas under the assumptions of kinetic theory allows the determination of the average force on container walls. This treatment assumes that the collisions with the walls are perfectly elastic and molecules do not collide with each other.



For N molecules

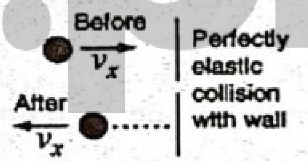
$$\overline{F} = \frac{m\left[v_{1x}^2 + v_{2x}^2 + v_{3x}^2 + \dots\ v_{Nx}^2\right]}{L}$$

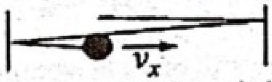
but this can be related to the average:

$$\overline{v_x^2} = \frac{\left[v_{1x}^2 + v_{2x}^2 + v_{3x}^2 + \dots\ v_{Nx}^2\right]}{N}$$

Force of molecular collision with wall

$$\overline{F}\Delta t = \Delta p = 2mv_x$$





The time for a "round trip" is $\Delta t = \dfrac{2L}{v_x}$

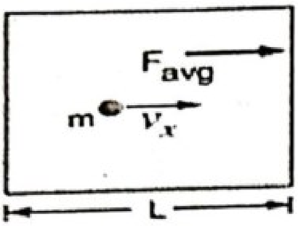
so the average force is $\overline{F} = \dfrac{2mv_x}{\dfrac{2L}{v_x}} = \dfrac{mv_x^2}{L}$

and for N molecules: $\overline{F} = \dfrac{mN\overline{v_x^2}}{L}$

In the expression for the average force from N molecules, it is important to note that it is the average of the square of the velocities which is used, and that this is distinctly different from the square of the average velocity.

Gas Pressure from Kinetic Theory:

Under the assumptions of kinetic theory, the average force on container walls has been determined to be



$$F_{average} = \frac{mN\overline{v_x^2}}{L}$$

and by using Maxwell law of velocities distribution we get;

$$\overline{v^2} = \overline{v_x^2} + \overline{v_y^2} + \overline{v_z^2} = 3\overline{v_x^2}$$

The average force and pressure on a given wall depends only upon the components of velocity toward that wall. But it can be expressed in terms of the average of the entire translational kinetic energy using the assumption that the molecular motion is random.

Then the pressure in a container can be expressed as

$$P = \frac{F_{avg}}{A} = \frac{mN\overline{v^2}}{3LA} = \frac{mN\overline{v^2}}{3V} = \frac{N}{3V}m\overline{v^2}$$

and hence the pressure is

$$P = \frac{2}{3}N_o < \frac{1}{2}mv^2 > \quad N_o = \frac{N}{V}$$

- Absolute temperature of a gas is measure of its average translational K.E of all gas molecules .

$$P = \frac{2}{3}\frac{N}{V}\langle K.E\rangle \ ; \ P\,\alpha\langle K.E\rangle \,or\, P\,\alpha\langle v^2\rangle$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$v_{rms} = \sqrt{\langle v^2\rangle} = \sqrt{\frac{3KT}{m}}$$

> **Do you know?**
> *Average speed of oxygen molecules in air at STP is $461 ms^{-1}$, and that for nitrogen is $493 ms^{-1}$*

SPECIFIC HEATS

- Amount of heat required to raise the temperature of a substance through 1 K is called *heat capacity*, denoted by C.
  Q = C m ΔT
- *Specific heat* is the amount of heat required to raise the temperature of unit mass through unit temperature.
  $Q = C_{sp}\ \Delta T$

Avagadro's law states:

"Equal volumes of gases at same temperature and pressure contain equal number of molecules."

> **Do you know?**
> *Molar specific heat of diatomic gas is greater than that of monatomic gas.*

Law of heat exchange states:

"If no heat is lost to surroundings or gained from it, then; ***Heat lost = Heat gained"***

INTRODUCTION TO THERMODYNAMICS

Thermodynamics is the study of the relationship between heat and other forms of energy.

- Thermodynamic states describe the state of a system.
- Any collection of matter having distinct boundaries is called *a system.*
- Boyle's law states that at constant temperature.
  PV=K(constant) or $P_1V_1=P_2V_2$
- Charle's law states that at constant pressure

$$\frac{V}{T} = K(constant) \quad or \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

- Sum of translational K.E, rotational K.E vibrational K.E and P.E due to intermolecular forces is called *internal energy.*
- Internal energy of an ideal gas system is the translational K.E of its molecules.
- Increase in temperature of the object is an indication of increase in the internal energy.
- Thermodynamic work at constant pressure is W= $P\Delta V$, *and* if pressure is not constant then $W = \sum_{\Delta V_i \to 0}^{n} P_i \Delta V_i$ *where* $n \to \infty$.

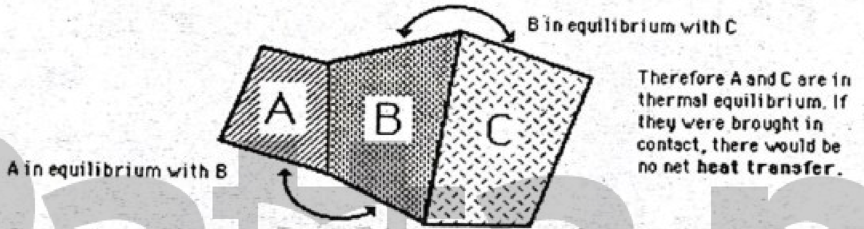
LAWS OF THERMODYNAMICS

Thermal Equilibrium:

It is observed that a higher temperature object which is in contact with a lower temperature object will transfer heat to the lower temperature object. The objects will approach the same temperature, and in the absence of loss to other objects, they will then maintain a constant temperature. They are then said to be in thermal equilibrium. Thermal equilibrium is the subject of the Zeroth Law of Thermodynamics.

Zeroth Law:

The "zeroth law" states that if two systems are at the same time in thermal equilibrium with a third system, they are in thermal equilibrium with each other.



If A and C are in thermal equilibrium with B, then A is in thermal equilibrium with B. Practically this means that all three are at the same temperature, and it forms the basis for comparison of temperatures. It is so named because it logically precedes the First and Second Laws of Thermodynamic

First Law

When heat is transformed into other forms of energy total heat remains constant.

$$\Delta Q = \Delta U + \Delta W$$

Where ΔQ is +ve when heat is added and vice versa.

ΔW is –ve when work is done by system and vice versa.

Inferences from 1st Law of Thermodynamics

- $\Delta U = \Delta Q - \Delta W$

$$\left(\begin{matrix}\textit{change in internal}\\ \textit{energy}\end{matrix}\right) = \left(\textit{Heat energy flowing in}\right) - \left(\begin{matrix}\textit{Heat energy flowing out}\\ \textit{as mechanical work}\end{matrix}\right)$$

- Internal energy is a state function. i.e. depends on initial and final states
- *For a cyclic process,* we have-

  $\Delta U = 0$, $U_i = U_f$, $\Delta Q = \Delta W$

Applications of 1st law of Thermodynamics

- **Isothermal process** is that in which temperature remains constant.

  $\Delta Q = \Delta W$ as $\Delta U = 0$
- **Isochoric process** is that in which volume remains constant.

  $\mathbf{\Delta Q = \Delta U}$ **as** $\mathbf{\Delta W = 0}$
- **Isobaric process** is that in which pressure remains constant.

  $\mathbf{\Delta Q = \Delta U + P\Delta V}$

- **Adiabatic process** is that in which no heat enters or leaves the system such that temperature remain constants: **$\Delta U = -W$ or $W = -\Delta U$**

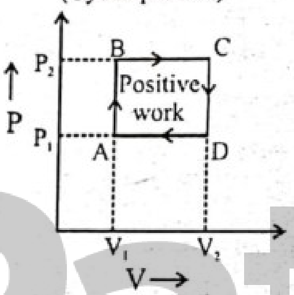
Note: *Cooling is produced when adiabatic expansion takes place and heating is produced during adiabatic compression.*
Adiabatic process is also termed as isentropic process i.e. a process in which the entropy of the system remains constant.
Rapid escape of air from automobile tyre is an example of adiabatic expansion.

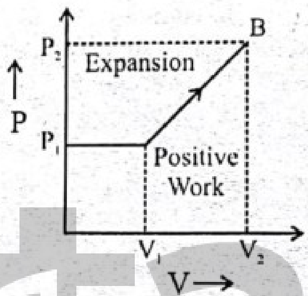
WORK

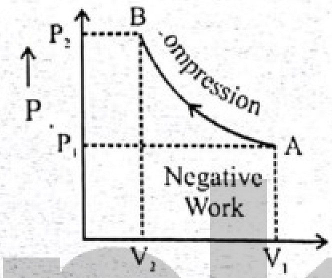
Work can be defined as the energy that is transferred one body to the other owing to a force that acts between them. The amount of work done by a system as it expands or contracts is given by: **$W = P\Delta V$**

- Work is taken to be positive if the system expands against some external force. Work is taken to be negative if the system contracts because of some external force exerted by the surroundings.
- **Work calculation by indicator-diagram method:** It is positive if volume increases and negative if volume decreases.

(Cyclic process)

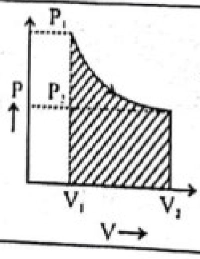
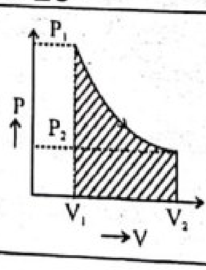
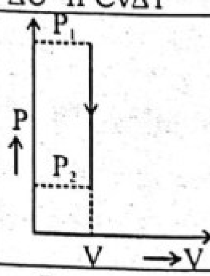
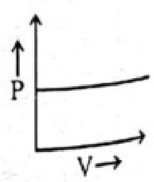






- If area under PV-diagram is traced in clockwise direction the work done will be positive (expansion) and will be negative (during compression) if the area is traced in anticlockwise direction.

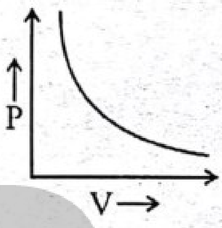
COMPARISON OF DIFFERENT THERMO DYNAMICAL PROCESSES

Sr. #	Property	Isothermal	Adiabatic	Isometric (Isochoric)	Isobaric
1.	Condition	T=constant, $\Delta T=0$, $\Delta U=0$	Q=constant, $\Delta Q=0$	V=constant, $\Delta V=0$, $\Delta W=0$	P=constant, $\Delta P=0$
2.	Form of first Law	$\Delta Q=0+\Delta W=P\Delta V$	$0=\Delta U+\Delta W$ $\Delta W=-\Delta U$	$\Delta Q=\Delta U+0$, $\Delta U=n\,C_v\Delta T$	$\Delta Q=\Delta U+\Delta W$ $=nC_p\Delta T$
3.	P.V Diagram				
4.	Equation of state	PV=constant	PV^{γ}=constant	$\frac{P}{T}$=constant	$\frac{V}{T}$=constant
5.	Specific Heat	$c=\infty$	$c=0$	$c=C_v$	$c=C_p$
6.	Slope of P.V curve	$\frac{\Delta P}{\Delta V}=-\frac{P}{V}$	$\frac{\Delta P}{\Delta V}=-\gamma\frac{P}{V}$	$\frac{\Delta P}{\Delta V}=\infty$	$\frac{\Delta P}{\Delta V}=0$
7.	Elasticity	$E_T=P$	$E=\gamma P$	$E=\infty$	$E=0$
8.	Operating condition for	Process should be completed	Process is to be completed rapidly	----	----

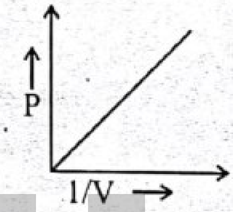
	process	very slowly	and the system should be surrounded by thermally insulated medium		
9.	Example	**(i)** Isothermal expansion of ideal gas, **(ii)** Conversion of ice at 0°C to water of 0°C	**(i)** Burst of air tube **(ii)** Propagation of sound in air **(iii)** Refrigeration	**(i)** To supply heat at constant volume, **(ii)**Atmospheric changes, **(iii)**Explosion in gases	**(i)** Melting of ice, **(ii)** Boiling of water

DIFFERENT THERMODYNAMIC AND RELATIVE PROCESSES

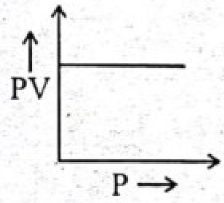
Thermodynamic processes



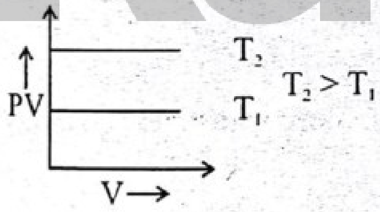
P–Vcurve

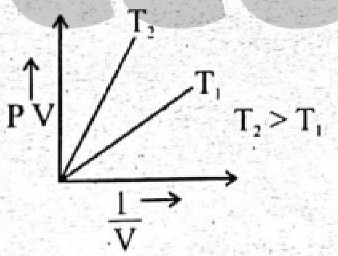


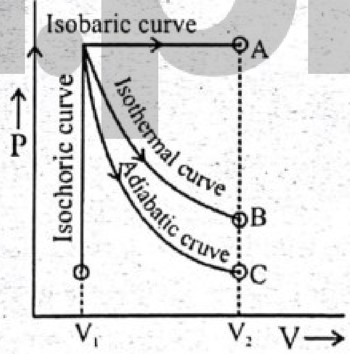
P–$\frac{1}{V}$ curve



P and PV curve







C_P is greater in value than C_V

- $\Delta Q_V = n\ C_V\ \Delta T$ (Heat supplied at constant volume).
- $\Delta Q_P = n\ Cp\ \Delta T$ (Heat supplied at constant pressure).
- $C_P - C_V = R$.
- $\frac{C_P}{C_V} = \gamma$

REVERSIBLE AND IRREVERSIBLE PROCESSES

- *Sequence of processes carried out in such a manner that the values of thermodynamic variables are retrieved at the end of processes then this process is called reversible process. Otherwise called irreversible.*
- *Liquefaction, evaporation and compression performed slowly* are reversible processes.

- *All changes that occur suddenly or involve friction or dissipation of energy through conduction, convection or radiation* are irreversible processes.

Second Law of Thermodynamics

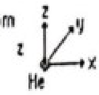
Kelvin Statement: "It is impossible to construct a heat engine which converts all heat energy absorbed from source without having a sink."

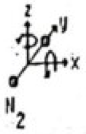
Clausius's Statement: *"It is impossible to transfer heat from cold to hot region without expenditure of external energy."*

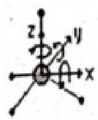
Refrigerator: A refrigerator is a heat engine in which work is done on a refrigerant substance in order to collect heat from a cold region and exhaust it in a higher temperature region, thereby further cooling the cold region.

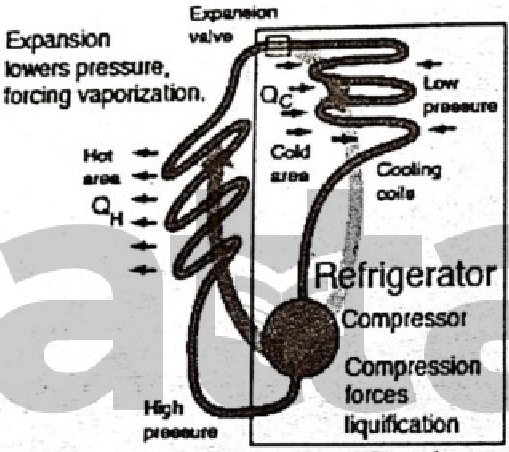
For Your Information

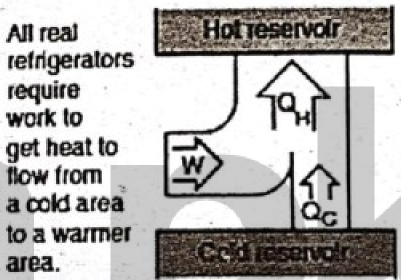
Degrees of freedom

3  Monoatomic $C_v = \frac{3}{2}R = 12.5 \frac{J}{mol\ K}$

5  Diatomic $C_v = \frac{5}{2}R = 20.8 \frac{J}{mol\ K}$

6  Polyatomic $C_v = \frac{6}{2}R = 24.9 \frac{J}{mol\ K}$





HEAT ENGINE

*H*eat engine is a thermodynamic device, which converts heat energy into mechanical energy.

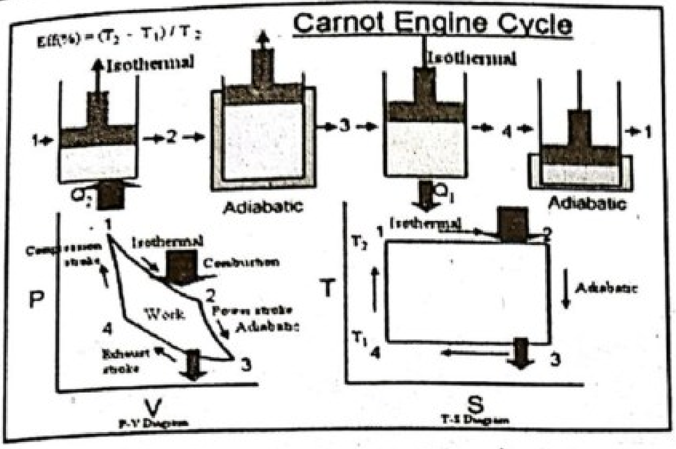
- There exists no perfect heat engine.
- Heat engine always operates in a cycle.
- *Cycle* means set of changes, which bring a system to its initial state.

CARNOT HEAT ENGINE

- Sadi Carnot proposed it in 1840. (ideal Engine).
- Carnot heat engine has maximum efficiency, but not 100%. $\eta_c = \left(1 - \frac{T_2}{T_1}\right) \times 100$
- Carnot cycle consists of following processes;

(i) Isothermal expansion **(ii)** Adiabatic expansion

(i) Isothermal compression **(iii)** Adiabatic compression



Do you know?
The area under the PV graph gives us the work done by the engine.

- Following things should be kept in mind about efficiency of Carnot engine: -

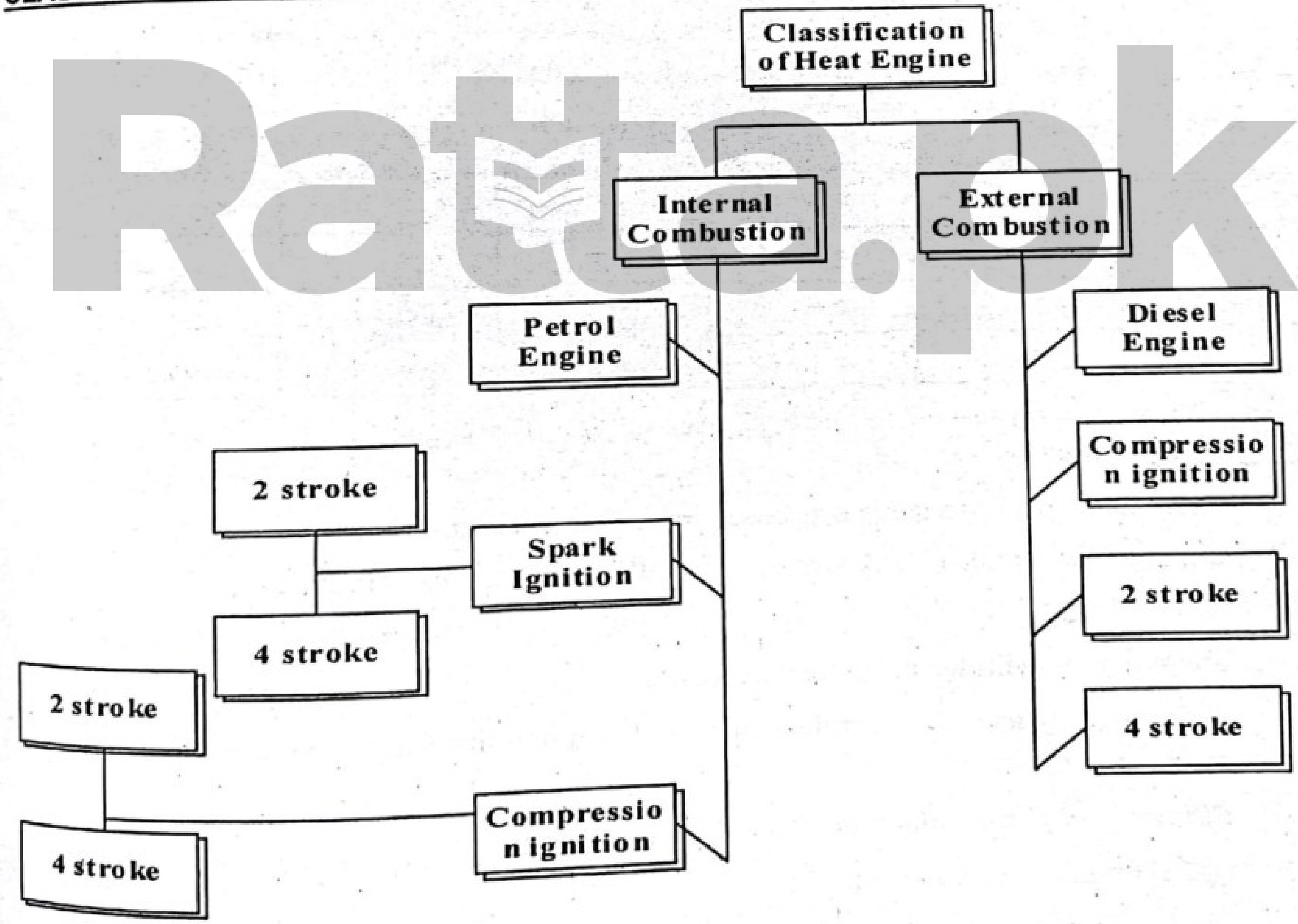
(i) It depends upon temperature difference between the source and the sink.

(ii) It is independent of nature working substance

(iii) It is 100% only when $T_2 = 0$ K

(iv) Carnot engine cannot be constructed practically.

CLASSIFICATION OF HEAT ENGINE

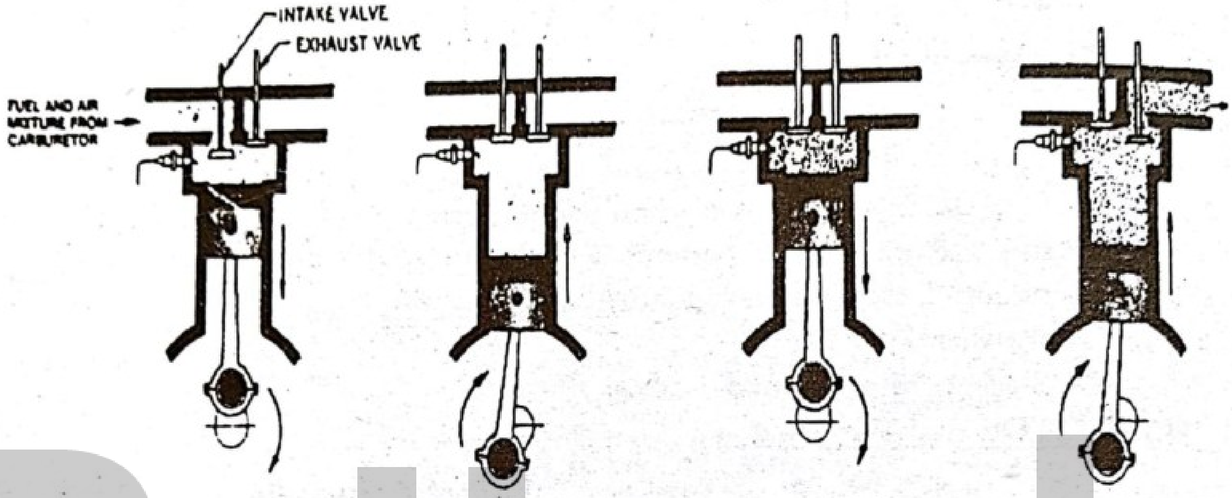


HEAT ENGINE

There are four major parts of every engine.

(i) Cylinder **(ii)** Piston **(iii)** Crank shaft **(iv)** Connecting rod

The piston oscillates within the constraints of the cylinder and this reciprocating movement is converted to rotary motion by the relative movement of crankshaft and connecting rod.



STORKE	DIRECTION	INTAKE VALVE	EXHAUST VALVE	GAS
INTAKE	DOWN	OPEN	CLOSED	ENTERS
COMPRESSION	UP	CLOSED	CLOSED	COMPRESSED
POWER	DOWN	CLOSED	CLOSED	BURNT
EXHAUST	UP	CLOSED	OPEN	EXPELLED

The Four-stroke-cycle Principle

PETROL ENGINE

- There are four successive processes in each cycle of a petrol engine.

(i) Charging stroke or intake stroke **(ii)** Compression stroke

(iii) Power stroke **(iv)** Exhaust stroke

- There is one cylinder in motorbike's engines.
- There usually are four cylinders in cars. Each one fire turn by turn for smooth running of the car.
- *Efficiency of petrol engine is about 25% to 30%.*
- Diesel engine has no spark plug.
- *Efficiency of diesel engine is about 35% to 40%.*

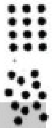
ENTROPY

- Degree of **disorderliness** is called *statistical entropy.*
- Unavailability of heat energy is called *thermo entropy.*

Law of increase of entropy: "Entropy of a thermodynamic system either remains constant (during reversible process) or it increases (during irreversible process)".

- We can represent change in entropy by following relation *given by Clausius.* $\Delta S = \dfrac{\Delta Q}{T}$

  Where ΔS is +ve if heat enters and vice versa.
- Its unit is JK^{-1}.
- Entropy may remain constant for a reversible process.
- Entropy increases for all irreversible processes.

Entropy:	A state variable whose change is defined for a reversible process at T where Q is the heat absorbed.	$\Delta S = \dfrac{Q}{T}$  Which came first?
Entropy:	A measure of the amount of energy which is unavailable to do work.	
Entropy:	A measure of the disorder of a system.	
Entropy:	A measure of the multiplicity of a system. (Point to ponder)	

ENVIRONMENTAL CRISIS AS ENTROPY CRISIS

- Entropy is a time arrow.
- Increase of entropy leads to heat death of universe because thermal pollution is an inevitable consequence of 2^{nd} law of thermodynamics.
- Environmental crisis is an entropy or disorder crisis resulting from our futile efforts to ignore the 2^{nd} law of thermodynamics

PRACTICE EXERCISE

30 mins Time Yourself

(1) **At absolute temperature, the K.E of the molecules**
(a) Become minimum
(b) become maximum
(c) Become zero
(d) None of these

(2) **Temperature is a property, which determines**
(a)How much heat a body contains
(b) Whether a body will feel hot or cold to touch
(c) In which direction heat will flow between two systems
(d) How much total absolute energy a body has

(3) **The force on the walls of a vessel of a contained gas is due to**
(a) the repulsive force between gas molecules
(b) elastic collisions between gas molecules
(c) a slight loss in the speed of a gas molecule during a collision with the wall
(d) a change in momentum of a gas molecule during a collision with the wall

(4) **The scales of temperature are based on two fixed points, which are**
(a) The temperatures of water at 0°C and 100°C
(b) The temperature of melting ice and boiling water at atmospheric pressure
(c) The temperatures of ice cold and boiling water
(d) The temperatures of frozen and boiling mercury

(5) **What does V represent in the equation $\frac{PV}{2} = RT$**
(a) Volume of n mole of gas
(b) Mass of 4g of gas
(c) Mass of 2gm of gas
(d) Volume of 2 mole of gas

(6) **Air is pumped into a bicycle tire at constant temperature. The pressure increases because:**
(a) the molecules are larger
(b) the molecules are farther apart
(c) more molecules strike the tire wall per second
(d) each molecule is moving faster

(7) **Normal human body temperature 98.6°F corresponds to**
(a) 37°C
(b) 42°C
(c) 55°C
(d) 410°C

(8) **In a system of N gas molecules, the individual speeds are $v_1, v_2, \ldots, v_n$. The rms speed of these molecules is:**
✓(a) $\sqrt{\frac{v_1^2 + v_2^2 \ldots\ldots\ldots v_N^2}{N}}$
(b) $\frac{\sqrt{v_1^2 + v_2^2 \ldots\ldots\ldots v_N^2}}{N}$
(c) $\frac{\sqrt{v_1 + v_2 \ldots\ldots\ldots v_N}}{N}$
(d) $\frac{\sqrt{v_1^2 + v_2^2 \ldots\ldots\ldots v_N^2}}{N^2}$

(9) **The average kinetic energy of the molecular motion appears as**
(a) P.E
(b) heat
(c) temperature
(d) none of these

(10) **Heating of water under atmospheric pressure is an**
(a) adiabatic process
(b) isothermal process
(c) isochoric process
(d) isobaric process

(11) **According to Pascal's law the pressure of gas in a vessel is**
(a) Different in different direction
(b) Same in all direction
(c) Same only along opposite directions
(d) Same only along normal directions

(12) The pressure of an ideal gas is doubled in an isothermal process. The root-mean-square speed of the molecules:

(a) increases by a factor of $\sqrt{2}$
(b) increases by a factor of 2
(c) decreases by a factor of $1/\sqrt{2}$
(d) does not change

(13) Which one is true for internal energy?

(a) It is sum of all forms of molecular energies of a system
(b) It is a state function of a system
(c) It is proportional to transnational K.E of the molecules
(d) All are correct

(14) The change in entropy is zero for

(a) reversible isothermal processes
(b) reversible adiabatic processes
(c) reversible processes during which no work is done
(d) reversible isobaric processes

(15) Which one is not an example of adiabatic process?

(a) rapid escape of air from a burst tyre
(b) rapid expansion of air
(c) conversion of water into ice in refrigerator
(d) cloud formation in the atmosphere

(16) For which combination of working temperatures the efficiency of Carnot's engine is highest?:

(a) 40 K, 20 K
(b) 100 K, 80 K
(c) 80 K, 60 K
(d) 60 K, 40 K

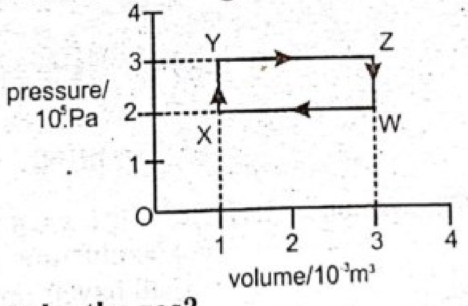
(17) A Carnot heat engine operates between 400K and 500K. Its efficiency is:

(a) 25%
(b) 44%
(c) 79%
(d) 20%

(18) If the volume of a gas is held constant and we increase its temperature then

(a) its pressure is constant
(b) its pressure rises
(c) its pressure falls
(d) all of above

(19) A gas undergoes the cycle of pressure and volume changes $W \rightarrow X \rightarrow Y \rightarrow Z \rightarrow W$ shown in the diagram.



What is the net work done by the gas?

(a) –600 J
(b) 200 J
(c) 0 J
(d) -200 J

(20) Boyle's law holds for ideal gases in

(a) isochoric processes
(b) isobaric processes
(c) isothermal processes
(d) adiabatic processes

(21) Gas molecules of different masses in the same container have the same average transnational kinetic energy, which is directly proportional to their

(a) volume
(b) pressure
(c) absolute temperature
(d) time

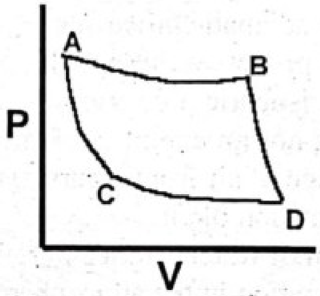
(22) **Which one is correct relation?**

(a) $C_p + C_v = \gamma$
(b) $C_p = 1 + \frac{R}{C_v}$
(c) $\gamma = \frac{C_p}{C_v}$
(d) $C_p = 1 - \frac{R}{C_v}$

(23) **The reading on the Fahrenheit scale will be double the reading on the centigrade scale when the temperature on the centigrade scale is**

(a) 460°C
(b) 280°C
(c) 360°C
(d) 160°C

(24) **The area enclosed by the curve ABDCA for a Carnot heat engine represents the work done by Carnot engine**



(a) at any instant
(b) averagely
(c) during its operation
(d) during one cycle

(25) **For a gas obeying Boyle's law, if the pressure is doubled, the volume becomes**

(a) double
(b) one half
(c) four times
(d) one fourth

(26) **During which process the volume of system remains constant**

(a) isothermal
(b) isobaric
(c) isochoric
(d) adiabatic

(27) **Which of the following properties of molecules of a gas is same for all gases at particular temperature?**

(a) momentum
(b) mass
(c) velocity
(d) kinetic energy

(28) **Boltzman constant K in terms of universal gas constant R and Avagadro's number N_a is given as**

(a) $K = RN_a$
(b) $K = \frac{R}{N_A}$
(c) $K = \frac{N_A}{R}$
(d) $K = nRN_a$

(29) **Which of the following phenomenon is the fastest for the transmission of heat**

(a) convection
(b) conduction
(c) radiation
(d) all have same speed for heat transmission

(30) **In which process entropy remains constant**

(a) isobaric
(b) isochoric
(c) adiabatic $\Delta S = 0$
(d) isothermal

(31) **Which statement of second law of thermodynamics is based on heat engine**

(a) Clausious statement
(b) Kelvin statement
(c) Carnot statement
(d) Boyles statement

(32) **Which quantity is not a thermodynamic state function**

(a) internal energy
(b) heat energy
(c) pressure
(d) volume

(33) **The value of γ for diatomic gas is**
(a) 1.67 (b) 1.4
(c) 1.3 (d) none

(34) **The work done in the isochoric process is**
(a) constant (b) variable
(c) zero (d) depends on situation

(35) **To help keep buildings cool in the summer, dark colored window shades have been replaced by light colored shades. This is because light colored shades:**
(a) reflect more sunlight (b) absorb more sunlight
(c) are more pleasing to the eye (d) transmit more sunlight

(36) **For the successful operation of Heat engine which condition should be met.**
(a) cyclic process (b) operated at certain temperature difference
(c) both (a) and (b) (d) petrol must be used

(37) **The performance of a refrigerator is described by**
(a) efficiency (b) coefficient of performance
(c) both (a) and (b) (d) not described

(38) **Two different samples have the same mass and temperature. Equal quantities of energy are absorbed as heat by each. Their final temperatures may be different because the samples have different:**
(a) heat capacities → not specific (b) volumes
(c) thermal conductivities (d) coefficients of expansion

(39) **1st law of thermodynamics is consequence of conservation of**
(a) work (b) energy
(c) heat (d) all of these

(40) **The rate of heat flow by conduction through a slab does NOT depend upon the:**
(a) Specific heat of the slab
(b) cross-sectional area of the slab
(c) thermal conductivity of the slab
(d) temperature difference between opposite faces of the slab

KIPS DIAGNOSTIC TEST

1	a	11	b	21	a	31	c	41	c	51	a
2	a	12	a	22	b	32	d	42	d	52	c
3	d	13	b	23	d	33	b	43	a	53	b
4	d	14	b	24	a	34	c	44	d	54	c
5	b	15	b	25	b	35	c	45	b	55	b
6	c	16	d	26	c	36	c	46	c	56	d
7	c	17	d	27	a	37	a	47	c	57	c
8	c	18	c	28	c	38	c	48	b	58	b
9	b	19	b	29	d	39	a	49	d	59	c
10	a	20	a	30	a	40	c	50	c	60	d

CHAPTER-1

1	d	11	d	21	a	31	b
2	a	12	a	22	b	32	b
3	b	13	a	23	b	33	b
4	d	14	b	24	d	34	a
5	a	15	d	25	a	35	a
6	a	16	b	26	b	36	d
7	a	17	d	27	a	37	d
8	d	18	c	28	b	38	a
9	d	19	b	29	d	39	c
10	c	20	c	30	d	40	c

CHAPTER-2

1	b	11	b	21	d	31	a
2	c	12	c	22	b	32	d
3	d	13	a	23	b	33	b
4	b	14	a	24	b	34	d
5	b	15	c	25	b	35	a
6	d	16	b	26	d	36	c
7	c	17	b	27	c	37	b
8	d	18	c	28	c	38	d
9	d	19	c	29	c	39	a
10	d	20	c	30	c	40	d

CHAPTER-3

1	b	11	d	21	c	31	a
2	d	12	a	22	b	32	b
3	c	13	d	23	a	33	a
4	c	14	d	24	b	34	b
5	d	15	a	25	a	35	d
6	b	16	a	26	b	36	a
7	a	17	c	27	c	37	a
8	a	18	b	28	a	38	a
9	c	19	c	29	b	39	d
10	d	20	c	30	a	40	b

CHAPTER-4

1	d	11	b	21	d	31	b
2	b	12	c	22	a	32	c
3	a	13	c	23	a	33	d
4	d	14	b	24	b	34	a
5	c	15	d	25	b	35	a
6	d	16	c	26	d	36	c
7	c	17	b	27	d	37	d
8	b	18	b	28	b	38	b
9	b	19	d	29	b	39	c
10	c	20	c	30	c	40	c

CHAPTER-5

1	a	11	b	21	d	31	b
2	b	12	c	22	d	32	c
3	c	13	c	23	b	33	c
4	d	14	d	24	c	34	b
5	a	15	c	25	b	35	b
6	b	16	c	26	c	36	b
7	b	17	a	27	c	37	d
8	d	18	a	28	a	38	b
9	b	19	b	29	a	39	c
10	c	20	d	30	b	40	c

CHAPTER-6

1	b	11	a	21	c	31	a
2	b	12	a	22	a	32	c
3	c	13	a	23	c	33	b
4	a	14	b	24	d	34	b
5	b	15	d	25	b	35	b
6	d	16	c	26	c	36	b
7	d	17	c	27	d	37	a
8	d	18	d	28	a	38	a
9	c	19	b	29	a	39	a
10	d	20	b	30	d	40	a

CHAPTER-7

1	c	11	c	21	b	31	d
2	b	12	c	22	d	32	a
3	c	13	c	23	d	33	b
4	a	14	b	24	c	34	d
5	c	15	c	25	d	35	c
6	d	16	d	26	a	36	a
7	c	17	d	27	d	37	b
8	c	18	b	28	d	38	c
9	d	19	c	29	c	39	a
10	a	20	b	30	c	40	c

CHAPTER-8

1	a	11	b	21	b	31	c
2	d	12	d	22	c	32	d
3	b	13	c	23	b	33	a
4	c	14	c	24	c	34	b
5	a	15	c	25	b	35	b
6	b	16	b	26	b	36	c
7	b	17	c	27	a	37	b
8	b	18	b	28	c	38	d
9	a	19	b	29	d	39	b
10	b	20	c	30	b	40	a

CHAPTER-9

1	b	11	c	21	d	31	d
2	c	12	d	22	d	32	c
3	c	13	c	23	a	33	a
4	d	14	c	24	b	34	d
5	d	15	c	25	c	35	a
6	d	16	c	26	c	36	c
7	c	17	b	27	b	37	d
8	c	18	b	28	d	38	b
9	d	19	b	29	c	39	a
10	b	20	c	30	a	40	c

CHAPTER-10

1	b	11	b	21	c	31	a
2	b	12	d	22	c	32	b
3	a	13	a	23	c	33	b
4	b	14	a	24	c	34	c
5	a	15	b	25	b	35	b
6	d	16	d	26	b	36	d
7	d	17	d	27	b	37	c
8	d	18	d	28	d	38	a
9	c	19	a	29	c	39	c
10	d	20	d	30	d	40	b

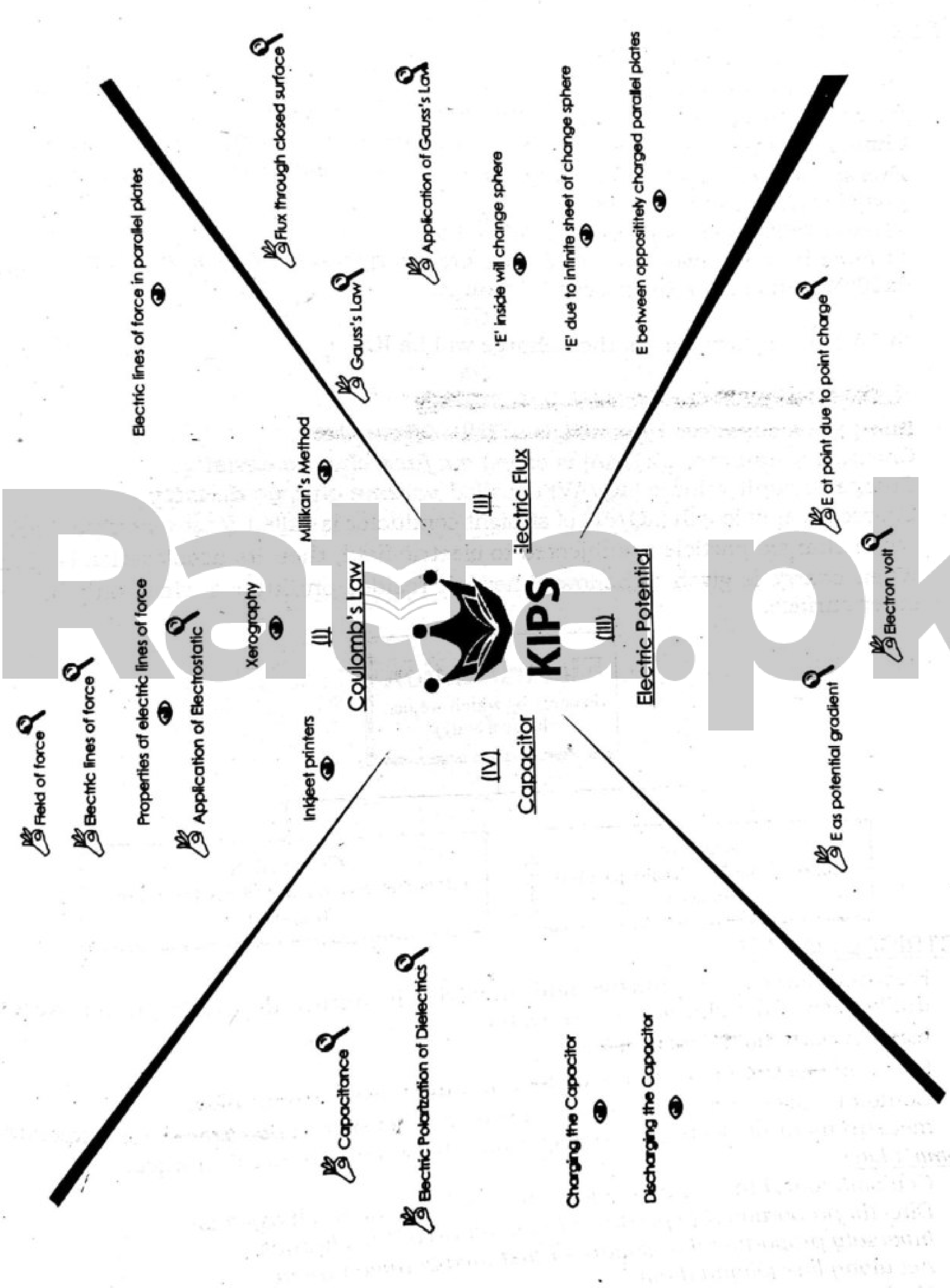
CHAPTER-11

1	c	11	b	21	c	31	c
2	c	12	d	22	c	32	b
3	d	13	d	23	d	33	b
4	b	14	b	24	d	34	c
5	d	15	c	25	b	35	a
6	c	16	a	26	c	36	c
7	a	17	d	27	d	37	b
8	a	18	b	28	b	38	a
9	c	19	b	29	c	39	b
10	d	20	c	30	c	40	a

KIPS ENTRY TEST SERIES

BOOK – II

KIPS PUBLICATION


KIPS
(I) Coulomb's Law
Field of force
Electric lines of force
Properties of electric lines of force
Application of Electrostatic
Xerography
Inkjeet printers
Millikan's Method
Electric lines of force in parallel plates
(II) Electric Flux
Flux through closed surface
Gauss's Law
Application of Gauss's Law
'E' inside will change sphere
'E' due to infinite sheet of change sphere
E between oppositely charged parallel plates
(III) Electric Potential
E at point due to point charge
Electron volt
E as potential gradient
(IV) Capacitor
Capacitance
Electric Polarization of Dielectrics
Charging the Capacitor
Discharging the Capacitor

- The physics that deals with charges at rest is called *electrostatics* and that which deals with moving charges is called electrodynamics.
- *An electric force* is the force, which holds the positive and negative charges that **make up atoms, molecules** and **bodies.**

CHARGE & ITS RELATIONSHIP WITH FRICTION

- Bodies get charge due to friction.
- During rubbing process, free or atomic electrons gain more energy than work function and get detached thus producing positive charge.
- **Similar charges repel each other while opposite charges attract each other.**
- *Excess of electrons* ***create negative charge*** *while their* ***deficiency produces positive*** *charge in an object.*
- *SI unit of charge is coulomb.* It is defined as:
  "If force between two equal and opposite charges placed in a vacuum 1m apart is 9×10^9N then each of them bear 1C charge."

  OR

  "If 1A current flows in 1 s then charge will be IC."

  OR

  "Charge of 6.25×10^{18} electrons is 1coulomb."
- **Charge is a conserved quantity as well as quantized**.

(i) Charge per unit area ($\Delta Q/\Delta A$) is called ***surface charge density.***
(ii) Charge per unit volume ($\Delta Q/\Delta V$) is called ***volume charge density.***
(iii) Charge per unit length ($\Delta Q/\Delta L$) of straight conductor is called ***linear charge*** *density.*

- When charged particle is subjected to electric field, then its acceleration is qE/m.
- When charge is given to hollow sphere, it resides on outer surface only but not on inner surface.

Electrification
(Process by which we can charge a body)

Induction
(Charge transfer without physical contact.)

Conduction
(Requires a physical contact for charge transfer)

ELECTRICAL FORCES

- Electrical forces are repulsive and attractive in nature depending upon likeness or unlikeness of the charges respectively.
- **Interaction of field explains force**.
- **Origin of electric force is provided by quantum electrodynamics**.
- Coulomb used an apparatus known as **torsional balance** for experimental measurement of electrical force operating between two point charges.

Coulomb's Law

Coulomb found that electrical force between two point charges is-
(i) *Directly proportional to product of magnitude of the charges.*
(ii) *Inversely proportional to square of distance between them*
(iii) *Act along line joining them.*

Mathematically,

$F_c = k\, q_1 q_2/r^2$

Where $K = 9 \times 10^9$ N-m²/C²

In vacuum, and using S.I units.

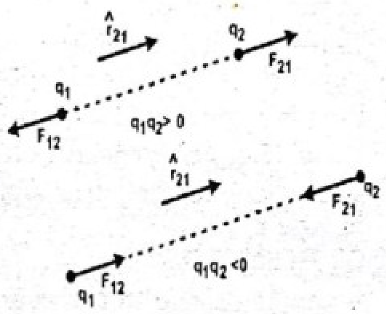
$k = 1/4\pi\epsilon_0$

Where ϵ_0 is permittivity of free space.

$\epsilon_o = 8.85 \times 10^{-12}\ C^2/N\text{-}m^2$

> **Do you know?**
> Two bodies having charge, very small in size as compared with the distance between them acts as *point charges*.

- $\vec{F}_{12} = -\vec{F}_{21}$ Shows that electrical forces form an action-reaction pair.
- Coulomb's law obeys **inverse square law**.
- *When charges are placed in medium other than air,* then force reduces by a factor ϵ_r known as **relative permittivity** of medium.



$$F' = \left(\frac{1}{\epsilon_r}\right)F$$

$$F' = \left(\frac{F}{\epsilon_r}\right)$$

- In terms of electrical force, ϵ_r can be given as; $\epsilon_r = \left(\frac{F}{F'}\right)$

  It means that *relative permittivity is ratio between electrical force between two point charges, when placed in air or vacuum to the electric force between them when placed in medium other than vacuum.*
- ϵ_r, the relative permittivity is unit less quantity.

ELECTRIC FIELD

Electric field is a vector quantity.

- It is intrinsic property of "charge" to have electric field around it.
- Two theories has been put forward to explain electric field -

(i) Action at a distance (Newton's view)

(ii) Field theory (Faraday's view)

- Action-at-distance has been rejected experimentally while field theory is a convincing view.
- *For infinite extent, field is uniform all over.*

  *For **finite extent**, **field is non-uniform at ends**. (Fringing Field)*

ELECTRIC INTENSITY

- Electric intensity is given as; **E = F/q₀**

  Where q_o is a test charge. It is defined as the force per unit positive charge.
- In vector form $\vec{E} = k\dfrac{q}{r^2}\hat{r}$ for a point charge.
- *SI unit of E is N/C and V/m*

ELECTRIC LINES OF FORCE

Definition:

The path followed by a tiny positive charge in an electric field is called electric intensity.

*Electric lines of force are imaginary lines **starting** from positive charge and **ending** on negative charge.*

Some of important properties are given below;

(i) Originate from positive charge.

(ii) End on negative charge.

(iii) Do not intersect
(iv) Contract longitudinally.
(v) Repel transversely.
(vi) No electric line is present inside the conductor.
(vii) Tangent drawn to electric lines gives the direction of electric intensity
(viii) Electric field is stronger where the electric lines are **closely packed**

XEROGRAPHY (PHOTOCOPIER)

- "Xeros" means **"dry"**, "graphy" means, **"writing"**.
- The lamp transfers the image of document as bright and dark spots on **drum** (core of the Machine).
- Drum is an aluminum cylinder coated with selenium. Selenium is a LDR (Light dependent resistor). It retains positive charge in dark.
- Positive charge document image is created on the drum.
- Toner is given negative charge and is sprayed over the drum.
- The image is then transferred on paper and is settled by the heated pressure rollers on the paper.

INKJECT PRINTERS

- It works on the thin stream of ink ejected from a nozzle at high speed.
- It passes through two electrical components. **Charging electrode** and **deflection plates.**
- Charging electrode gives a net charge to the stream controlled by instructions from computers.
- The uncharged drops pass without deflection through deflection plates and strike the paper while charged drops are directed to gutter.

ELECTRIC FLUX

Electric flux is the number of electric lines of force passing perpendicular through certain area.

- Mathematically electric flux is defined as;
  $\phi_e = \overline{E} \cdot \overline{A} = EA\cos\theta$ provided E is uniform on flat surface represented by $\overline{A}$.
- It is a scalar quantity.
- $\phi_{max} = EA$ when $\theta = 0°$ (surface is $\perp$ to E)
  $\phi_{min} = 0$ when $\theta = 90°$ (surface is $\|$ to E)
- If no. of flux lines leaving a closed surface is greater than no. of flux lines entering, then surface contains source or positive charge.
- If no. of flux lines leaving a closed surface is less than no. of flux lines entering it, then surface contains sink or negative charge.
- If no. of flux lines entering is equal to no. of flux line leaving, then surface contain neither sink nor source.

Do you know?
Electric flux depends upon charge and medium not on shape of the closed surface.

FLUX THROUGH CLOSED SURFACE

- Flux through closed surface is;
  $\phi_e = Q/\epsilon_o$
  It shows that flux through closed surface is independent of **location** of charges enclosed by it and **shape** of closed surface.

POINT TO PONDER
Any apparatus placed within a metal enclosure is shielded from electric fields. Why?

GAUSS'S LAW

"The flux through a closed surface is $\left(\frac{1}{\epsilon_o}\right)$ times the total charge enclosed in it".

$$\phi_{total} = \left(\frac{1}{\epsilon_o}\right)Q$$

Gauss's Law is applied to calculate electric intensity. For this purpose an imaginary closed surfaced called Gaussian surface is considered which must pass through the point at which the electric intensity is to be evaluated.

Applications

(i) Electric intensity inside a hollow but uniformly charged sphere is zero. $\mathbf{E} = 0$

(ii) Electric intensity due to **infinite sheet of charge** is given as; $\overline{E} = \frac{\sigma}{2\epsilon_o}\hat{r}$

(iii) Electric intensity between **two equal but oppositely charged** plates is given as.

$$\overline{E} = \frac{\sigma}{\epsilon_o}\hat{r}$$

// two // // similar // //
$\overline{E} = 0$ $\phi = 0$

Electrical Potential *OR Potential* Difference

Electric potential difference between two points is defined as:
"Work done per unit positive charge in moving it against electric field with uniform velocity. i.e. keeping the charge in electrostatic equilibrium."

$$\Delta V = \frac{W_{A\to B}}{q_o}$$

- It can be given in terms of potential energy as

$$\Delta V = \frac{\Delta U}{q_o} \qquad \because W_{A\to B} = \Delta U = \text{electrostatic P.E}$$

- SI unit of potential difference is volt.
"If 1J of work is done on one coulomb charge between two points keeping the equilibrium, the potential difference is 1V"

1V = 1J/1C

> **For your information**
>
> We can relate electric potential difference and electric field intensity by following relation: $E = -\frac{\Delta V}{\Delta r}$
>
> Where negative shows that E is along decreasing potential N/C is equal to V/m.
>
> It means that-
>
> **(i)** We can call 'E' potential gradient because it represents the maximum rate of change of potential difference w.r.t displacement.
>
> **(ii)** SI unit of E (N/C) is equivalent to V/m. $\frac{1N}{1C} = \frac{1V}{1m}$

- **Absolute electric potential** at a distance 'r' from source is given as;

$$V_{(r)} = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$$

- **Absolute potential** at a point due to collection of point charges is given as;

$$V=\frac{1}{4\pi\varepsilon_o}\sum_{i=1}^{n}\frac{q_i}{r_i}$$

- **ECG** records the voltage between points on human skin generated by electrical process in the heart while EEG records that by brain.

EQUIPOTENTIAL SURFACES

Definition:

The surface on which electric potential is same at each of its points is called equipotential surface.

Example:

Surface of the charged hollow sphere containing point charge at its center

- ***Characteristics of equipotential surfaces***

(i) They do not intersect.

(ii) Potential difference between two **points on equipotential surface** is zero.

(iii) No work is done to move a point charge on an equipotential surface.

(iv) Work is done when point charge is moved from one equipotential surface to another.

ELECTRON VOLT

Definition:

The amount of energy acquired or lost by an electron as it traverses a potential difference of one volt.

- $1eV = 1.6\times10^{-19}J$ and $1J = 6.25\times10^{18}$ eV
- It is the unit of energy specially used for atomic particles.

COMPARISON OF GRAVITATIONAL AND ELECTROSTATIC FORCES

Particulars	Gravitational force	Electrostatic force
Formula	$F_g = Gm_1m_2/r^2$	$F_e=\frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r^2}$
Range	Infinite	infinite
Symbol of constant	G	$k=\frac{1}{4\pi\varepsilon_o}$
Value of constant	Very small	Fairly large
Nature	Always attractive	Attractive or repulsive
Dependence	Medium independent	Medium dependent
Relative strength	Weak: can be felt with massive object	Strong at close range

MILLIKAN'S METHOD FOR ELECTRON'S CHARGE

- Atomizer sprays oil droplets
- The droplet between the two plates could be suspended in air if the gravitational force $F_g = mg$ acting downward on the droplet is equal to the electrical force $F_e = qE$ acting upward. $qE = mg$

and $E=\frac{V}{d}$, $\Rightarrow$ $q=\frac{mgd}{V}$

- The terminal velocity is determined by timing the fall of the droplet over a measured distance. Minimum quantum charge is of electron i.e. $1.6\times10^{-19}C$

CAPACITOR & CAPACITANCE

- Capacitor is a device used for **storing electric charge** and electrical energy.
- Charge stored by capacitor is given as; $Q = CV$

Where C is **capacitance of** capacitor

- **Capacitance is defined as:** Ability of a capacitor to store charge. **OR**
  "The ratio of charge stored to the potential difference between plates of capacitor."
- Mathematically, $C = \frac{Q}{V}$
- SI unit of capacitance is **farad.**
- **1 farad** is defined as;
  The capacitance of a capacitor is one farad if a charge of one coulomb, given to one of the plates of a parallel plate capacitor, produces a potential difference of one volt between them. $1F = \frac{1C}{1V}$

  ↳ Induces
- Capacitance of parallel plate capacitor with air between its plates is given as; $C_{vac} = \varepsilon_o \frac{A}{d}$
- The above expression shows that:-
- As we increase the area of plate the capacitance will increase.
- Decreasing the distance between plates will increase the capacitance.
- Introducing a dielectric between the plates will increase the capacitance of the capacitor.
- Capacitance of an isolated charge sphere of radius R is $C = 4\pi \in_o R$.
- Capacitance of a parallel plate capacitor with dielectric between its plate is given as;

$$C_{med} = \varepsilon_r \varepsilon_o \frac{A}{d} = \varepsilon_r C_{vac} \quad \text{so} \quad C_{med} > C_{vac}$$

DIELECTRIC CO-EFFICIENT OR DIELECTRIC CONSTANT

Definition:

The ratio of the capacitance of a parallel plate capacitor with an insulating substance as medium between the plates to its capacitance with vacuum (or air) as medium between them.

$$\varepsilon_r = \frac{C_{med}}{C_{vac}}$$

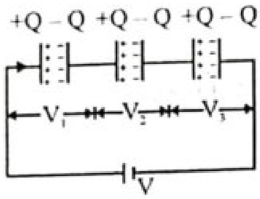
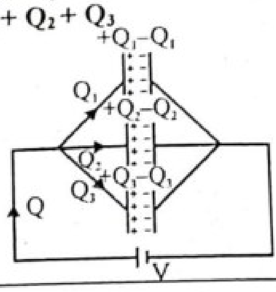
- *Charging of capacitor is due to electrostatic induction phenomenon.*
- Old name of capacitor is condenser.

Types of capacitor

(i) Parallel plate capacitor
(ii) Spherical capacitor
(iii) Miniature capacitor
(iv) Tubular capacitor.
(v) Paper capacitor
(vi) Electrolytic capacitor
(vii) Variable capacitor.

COMBINATIONS OF CAPACITORS

SERIES GROUPING	PARALLEL GROUPING
• Capacitors are said to be connected in series between two points when we can proceed from one point to the other only through one path. **OR**	• The capacitors are said to be connected in parallel between any two points if we proceed from one point to the other along different paths. **OR**
• In series grouping charge on each capacitor remains same and equals to the main charge supplied by the battery but potential difference across them may or may not be same.	• In parallel grouping potential difference across each capacitor remains same and equal to the applied potential difference

	while charge on them may or may not be same.
• Charge on each capacitor remains same and equals to the main charge supplied by the battery. $V = V_1 + V_2 + V_3$ 	• Potential difference across each capacitor remains same and equal to the applied potential difference $Q = Q_1 + Q_2 + Q_3$ 
• Equivalent capacitance $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ or $\frac{1}{C_{eq}} = \left(C_1^{-1} + C_2^{-1} + C_3^{-1}\right)$	$C_{eq} = C_1 + C_2 + C_3$
• In series combination potential difference and energy distribution is in the reverse ratio of capacitance, i.e., $V \propto \frac{1}{C}$ and $P.E \propto \frac{1}{C}$	• In parallel combination charge and energy distributes in the ratio of capacitance i.e. $Q \propto C$ and $P.E \propto C$
• If two capacitors having capacitance C_1 and C_2 are connected in series then $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$	• If two capacitors having capacitance C_1 and C_2 are connected in series then $C_{eq} = C_1 + C_2$
• If n identical capacitors each having capacitances C are connected in series with supplied voltage V then equivalent capacitance $C_{eq} = \frac{C}{n}$	• If n identical capacitors are connected in parallel $C_{eq} = nC$

ELECTRIC POLARIZATION

Polarization is a phenomenon of appearance of opposite charges on surface of a material subjected to **electric field.**

- Polarization charges are called *induced charges*
- *Dipole* is a set of two equal and opposite charges separated by a small distance 'r.'

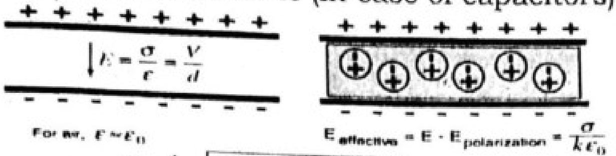
$$\overset{\longleftarrow\!\bullet\!\longrightarrow}{+q \qquad\qquad -q}$$

- *Some substance are polar* i.e. they have **permanent dipoles** e.g. in NaCl, the end with **Na** ion is **positive** while that with **Cl** ion is **negative.**
- *Some substances are* ***non-polar*** i.e. they do not have **permanent dipoles** e.g. plastic. *They become polarized* ***temporarily*** *when subjected to* ***external field.***
- *Polar molecules experience torque when subjected to uniform electric field but zero net force. In non-uniform electric field it* ***also experiences net force*** *in addition* ***to torque.***

DIELECTRICS

- *Dielectrics are* ***non-polar insulators.***
- Polarized dielectrics produce electric field opposite to the applied electric field.

- Molecular view of a polarized dielectric (in case of capacitors) is shown below;



$$C = \frac{\varepsilon_0 A}{d}$$ The capacitance is increased by the factor k. $$C = \frac{k\varepsilon_0 A}{d}$$

; $k = \epsilon_r$

It shows that *a* ***static equilibrium*** *exists within the dielectric.*

Effect of Dielectrics on Various Electrical Quantities

F'	$= F / \epsilon_r$	(decreases)
E'	$= E / \epsilon_r$	(decreases)
V'	$= V / \epsilon_r$	(decreases) $V = \frac{1}{4\pi\epsilon_0\epsilon_r} q/r$
C'	$= C \epsilon_r$	(increases)

Do you know?
Value of ε_r for all dielectrics is greater than 1 except for air.

EFFECT OF POLARIZATION ON CAPACITANCE

- The electric polarization of dielectric increases the capacitance.
- The electrons in the dielectric (insulator) remain bounded to their respective atoms. They are just displaced from their normal positions.
- The molecules of the dielectric under the action of electric field become diploes and dielectric is polarized.
- *As $E = \sigma/\epsilon_o$, so electric field between capacitor plates decreases due to* ***polarization of dielectric.***
- *Decrease in E decreases the* ***potential difference*** because $V = Ed$.
- *As a result capacitance increases*

ENERGY STORED IN A CAPACITOR

- Charge on the plate of capacitor **possesses electrical potential energy** because of the work done to deposit the charge on the plates.
- $P.E = \frac{1}{2}qV$

  Energy in capacitor $= \frac{1}{2}CV^2 = \frac{1}{2}\frac{q^2}{C}$
- Energy is stored in electric field between the plates.
- Energy $= \frac{1}{2}\left[\frac{A \epsilon_r \epsilon_o}{d}\right][Ed]^2$
- Energy Density = Energy/volume $= \frac{1}{2}\epsilon_r\epsilon_o E^2$

Do you know?
- *For D.C, capacitor behaves as open circuit*
- *For A.C, capacitor behaves as closed circuit.*

CHARGING AND DISCHARGING A CAPACITOR

- *D.C supply stores charges on the plate*
- A.C supply does not store charge
- Charging and discharging time depends upon product of R & C

Time constant

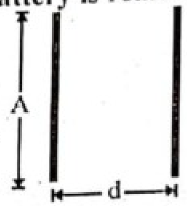
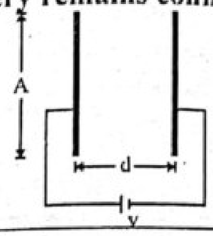
$$t = RC$$

Its unit is 's' i.e. second.

- Time constant is defined as the time required by a capacitor to charge up to 0.63 times the equilibrium charge on the capacitor.
- Charge reaches its equilibrium value **sooner** when time constant is smaller.

- Windshield wipers of car work by charging and discharging of capacitor.

A) SEPARATION IS INCREASING

Quantity	Battery is removed	Battery remains connected
		
Capacity	Decreases because $C = \frac{1}{d}$ i.e., $C' < C$	Decreases i.e., $C' < C$
Charge	Remains constant because a battery is not present i.e., $q' = q$	Decreases because battery is present i.e., $q' < q$. $C = Q/V$ As V = const And $C\downarrow$ so $Q\downarrow$
Potential difference	Increases because $V = \frac{q}{C}$ $\Rightarrow$ $V \propto \frac{1}{C}$ i.e., $V' > V$	$V' = V$ (since battery maintains the potential difference)
Electric field	Remains constant because $E = \frac{\sigma}{\varepsilon_o} = \frac{q}{A\varepsilon_o}$ i.e., $E' = E$	Decrease because $E = \frac{q}{A\varepsilon_o}$ $\Rightarrow$ $E \propto q$ i.e., $E' < E$
Energy	Increases because $U = \frac{q^2}{2C}$ $\Rightarrow$ $U \propto \frac{1}{C}$ i.e., $U' > U$	Decreases because $U = \frac{1}{2}CV^2$ $\Rightarrow$ $U \propto C$ i.e., $U' < U$

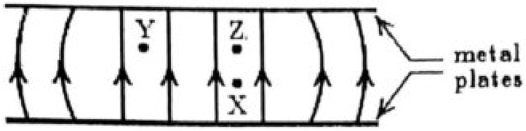
B) SEPARATION IS DECREASING

Quantity	Battery is removed	Battery remains connected
Capacity	Increases because $C = \frac{1}{d}$ i.e., $C' > C$	Increases i.e., $C' > C$
Charge	Remains constant because battery is not present i.e., $q' = q$	Increase because battery is present i.e., $q' > q$. Remaining charge $(q' - q)$ supplied from the battery.
Potential difference	Decreases because $V = q/C$ $\Rightarrow$ $V \propto \frac{1}{C}$ i.e., $V' < V$	$V' = V$ (since battery maintains the potential difference)
Electric field	Remains constant because $E = \frac{\sigma}{\varepsilon_o} = \frac{q}{A\varepsilon_o}$ i.e., $E' = E$	Increases because $E = \frac{q}{A\varepsilon_o}$ $\Rightarrow$ $E \propto q$ i.e., $E' > E$
Energy	Decreases because $U = \frac{q^2}{2C}$ $\Rightarrow$ $U \propto \frac{1}{C}$ i.e., $U' < U$	Increases because $U = \frac{1}{2}CV^2$ $\Rightarrow$ $U \propto C$ i.e., $U' > U$

PRACTICE EXERCISE

30 mins Time Yourself

(1) **The diagram shows the electric field lines due to two charged parallel metal plates. We conclude that:**



(a) the upper plate is positive and the lower plate is negative
(b) a proton at X would experience the same force if it were placed at Y
(c) a proton at X experiences a greater force than if it were placed at Z
(d) a proton at X experiences less force than if it were placed at Z

(2) **If the distance between the two point charges become half, then force between them becomes ________**
(a) double
(b) half
(c) four times
(d) remains same

(3) **The minimum charge on any object cannot be less than____________**
(a) $1.6x10^{-19}C$
(b) $3.2x10^{-19}C$
(c) $9.1x10^{9}C$
(d) no definite value exist

(4) **An isolated charged point particle produces an electric field with magnitude E at a point 2m away. At a point 1m from the particle the magnitude of the field is:**
(a) 2E
(b) 4E
(c)3E
(d)E

(5) **The purpose of Millikan's oil drop experiment was to determine**
(a) the charge of an electron
(b) the mass of an electron
(c) the ratio of charge to mass for an electron
(d) the sign of the charge on an electron

(6) **Two charges are placed at a certain distance. If the magnitude of each charge is doubled, the force will become**
(a) $1/4^{th}$ of its original value
(b) $1/8^{th}$ of its original value
(c) 4 times of its original value
(d) 8 times of its original value

(7) **The force per unit charge is known as ____________**
(a) electric flux
(b) electric intensity
(c) electric potential
(d) all of above are same

(8) **An electric field can deflect ______________**
(a) neutrons
(b) γ-rays
(c) X-rays
(d) none

(9) **An electric charge at rest produces____________**
(a) only a magnetic field
(b) only an electric field
(c) neither electric field nor magnetic field
(d) both electric and magnetic fields

(10) **If a unit positive charge is placed in air then the flux coming out of it is**
(a) $4\pi\varepsilon_0$
(b) ε_0^{-1}
(c) ε_0
(d) $4\pi/\varepsilon_0$

(11) A point particle with charge q is at the center of a Gaussian surface in the form of a cube. The electric flux through any one face of the cube is

Imp

(a) $\frac{q}{\varepsilon_o}$ (b) $\frac{q}{6\varepsilon_o}$

(c) $\frac{q}{4\varepsilon_o}$ (d) $\frac{q}{4\varepsilon_o}$

(12) Electric flux linked with a surface will be maximum when

(a) 60^0 (b) 90^0

(c) 30^0 (d) 0^0

(13) The unit of $\acute{\varepsilon}_r$

(a) $Nm^{-1}A^{-1}$ (b) $N^{-1}m^{1}C^{2}$

(c) $Nm^{2}C^{2}$ (d) No unit

(14) The electric lines of force are ______________

(a) imaginary (b) physically existing every where

(c) physically existing near the charges (d) depends upon case

(15) Two 2μF capacitors are connected in parallel then the equivalent capacitance will be

(a) 2μF (a) $\frac{1}{2}$ μF

(c) $\frac{1}{4}$ μF (d) 4 μF

(16) A capacitor of capacitance C has charge Q and stored energy is W. If the charge is increase to 2Q. The stored energy will be

(a) W/4 (b) W/2

(c) 2W (d) 4W

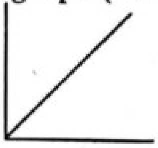
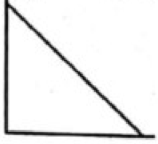
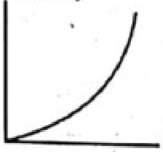
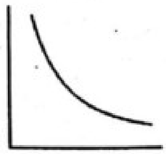
(17) Two similar charges each of one coulomb placed in air one meter apart repel each other with a force

(a) $9\text{x}10^{9}$N (b) $9.2\text{x}10^{4}$N

(c) $9\text{x}10^{-9}$N (d) $9\text{x}10^{7}$N

(18) The variation of electric potential due to a point charge with distance is represented by the graph (where V along y-axis and r along x-axis)

Imp

(a)  (b)  (c)  (d) 

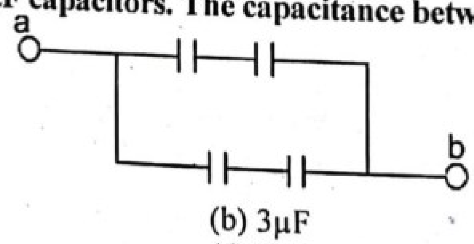
(19) A capacitor C "has a charge Q". The actual charges on its plates are

Imp

(a) Q, −Q (b) Q, Q

(c) Q/2, −Q/2 (d) Q, 0

(20) The diagram shows four 6-μF capacitors. The capacitance between points a and b is:



(a) 6μF (b) 3μF

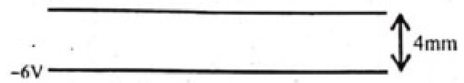
(c) 4μF (d) 9μF

(21) A gold nucleus (radius r) is represented by the symbol $^{197}_{79}Au$. Taking e as the elementary charge and ε_o as the permittivity of free space, what is the electric field strength at the surface of an isolated gold nucleus?

(a) Zero
(b) $\frac{197e}{4\pi\varepsilon_o r^2}$
(c) $\frac{79e}{4\pi\varepsilon_o r^2}$
(d) $\frac{79e^2}{4\pi\varepsilon_o r^2}$

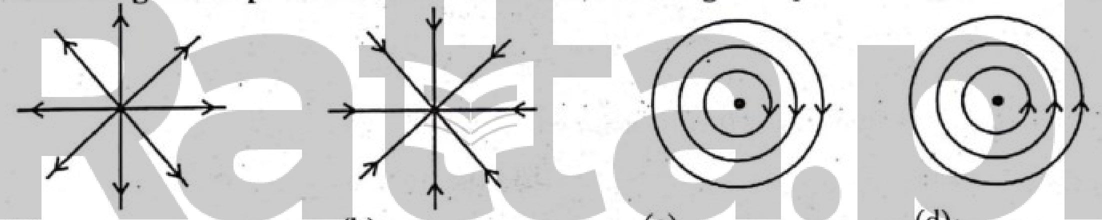
(22) In EEG, voltage is plotted versus time. This voltage is produced by electrical activity of
(a) joints in human body
(b) spinal cord
(c) brain
(d) applied battery

(23) The large horizontal metal plates are separated by 4 mm. The lower plate is at a potential of –6V.



What potential should be applied to the upper plate to create an electric field of strength 4000 Vm^{-1} Upwards in the space between the plates?
(a) +22 V
(c) –10 V
(b) +10 V
(d) –22 V

(24) Which diagram represents the electric fields of a negative point charge, shown by •



(a) (b) (c) (d)

(25) A 5 μF capacitor has a potential difference across its plates of 200 volts. The charge on the capacitor is
(a) 2.5×10^{-8} C
(b) 10^{-3} C
(c) 10^{3} C
(d) 4×10^{3} C

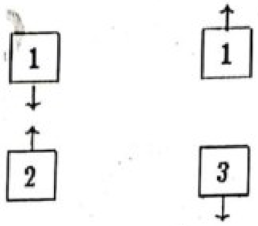
(26) The quantity $\frac{1}{2}\varepsilon_o E^2$ has the significance of:
(a) energy/farad
(b) energy/coulomb
(c) energy/volume
(d) energy

(27) Equivalent capacitance is greater than individual capacitances in
(a) series combination
(b) parallel combination
(c) both series and parallel combinations
(d) none of above

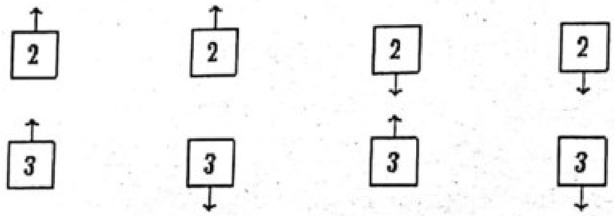
(28) If the distance between the plates of parallel plates condenser is increased, its potential will
(a) Remain same
(b) increase
(c) decrease
(d) decreases exponentially

(29) The number of electrons in one coulomb charge is equal to
(a) 6.2×10^{18}
(b) 1.6×10^{-19}
(c) 6.2×10^{21}
(d) 1.6×10^{-27}

(30) **The diagram shows two pairs of heavily charged plastic cubes. Cubes 1 and 2 attract each other and cubes 1 and 3 repel each other**



Which of the following illustrates the forces of cube 2 on cube 3 and cube 3 on cube 2?



A B C D

(31) **SI unit of permittivity of free space is**

(a) Nm^2C^2 (b) $N^{-1}mC^{-2}$

(c) NmC^{-1} (d) $N^{-1}m^{-2}C^2$

(32) **Value of ε_r for various dielectrics is always**

(a) less than unity (b) equal to unity

(c) larger than unity (d) no hard and fast rule

(33) **The leaves of a positively charged electroscope diverge more when an object is brought near the knob of the electroscope. The object must be:**

(a an insulator (b) a conductor

(c) negatively charged (d) positively charged

(34) **Two thin infinite parallel plates have uniform charge densities + σ and -σ . The electric field in the space between them is**

(a) $\sigma/2\varepsilon_0$ (b) σ/ε_0 (c) σ (d) zero

(35) **Electric flux due to a point charge +q is**

(a) $1/4\pi\varepsilon_o \cdot q/r$ (b) q/ε_o

(c) $1/4\pi\varepsilon_o \cdot q/r^2$ (d) $4\pi\varepsilon_o$

(36) **N/C=**

(a) V/A (b) Vm

(c) V/m (d) A/m

(37) **A charge of 0.10C accelerated through a potential difference of 1000V acquires kinetic energy**

Ans (a) 200 J

(b) 10 J

(c) 100 J

(d) 100 eV $\frac{1}{2}mv^2 = \frac{1}{2}CV^2$

(38) **A capacitor is a perfect insulator for**

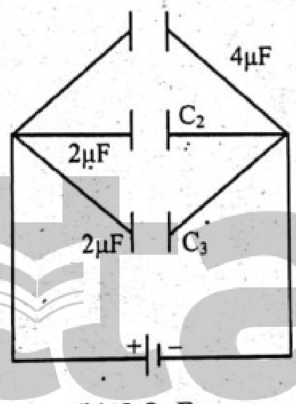
(a) direct current

(b) alternating current

(c) both for the direct and alternating current

(d) rapidly fluctuating current

(39) **Three capacitors C_1, C_2 and C_3 are connected in parallel as in the Fig. The equivalent capacitance will be**



(a) 8μF

(b) 0.8μF

(c) 1μF

(d) 16μF

(40) **In a charged capacitor the energy resides in**

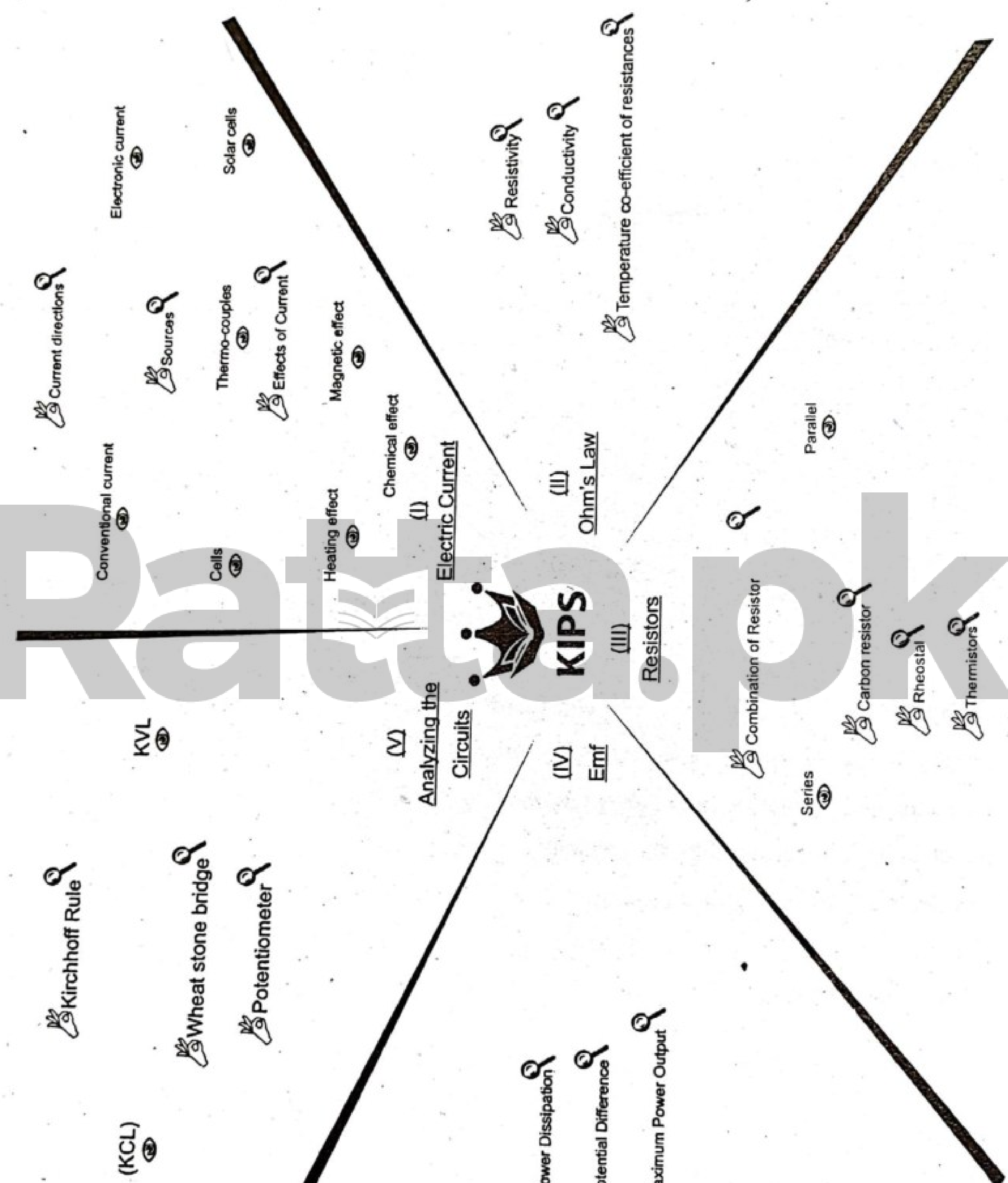
(a) electric field surrounding the capacity

Ans (b) electric field inside the capacitor

(c) both "a" and "b"

(d) gravitational field

Chapter 13 CURRENT ELECTRICITY



ELECTRIC CURRENT

- The rate of flow of charge in a circuit is defined as current.

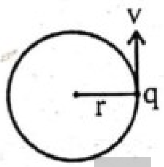
  i.e. $\text{Current} = \dfrac{\text{Charge}}{\text{Time}}$ or $I = \dfrac{Q}{t}$ or $Q = It$
- Electric current is equal to charge that flows in one second.
- Electric current is a scalar quantity.
- Unit of current is ampere in M.K.S. system and stat ampere in C.G.S. system.

  and $1\ \text{ampere} = 3\times10^{9}$ stat ampere
- 1 ampere = 6.25×10^{18} electrons / second.
- Direction of current is from higher to lower potential. The direction of current is in the direction of flow of positive charge and opposite to the direction of flow of negative charge.
- In metals electric conduction takes place due to flow of free electrons only. But in gases and electrolytes, electric conduction takes place due to flow of both positive and negative ions.

Charge moving in a Circle: If a charged particle of charge q is moving in circular path of radius r with constant speed v and constant frequency f, then

Current produced $I = fq$

or $I = \dfrac{vq}{2\pi r}$ $\left(\because\ f = \dfrac{v}{2\pi r}\right)$



CONVENTIONAL & ELECTRONIC CURRENT

CONVENTIONAL CURRENT	ELECTRONIC CURRENT
Current due to positive charges is called conventional current	Current due to electrons or negative charges is called electronic current.
It flows from higher to lower potential	It flows from lower to higher potential.
It flows in direction along the direction of field.	It flows in direction against the direction of field.

- both conventional and electronic currents are flowing in a circuit, then total current will be given as; $I_{total} = I_{+ve} + I_{-ve}$
- **Drift velocity (V_d):** It is the average velocity attained by free electrons on applying external electric field. In conductors, $v_d = 10^{-3}\,\text{ms}^{-1}$
- **Mean free Path (λ):** It is the average distance moved by a free electron between two successive collision with stationary positive ions.
- **Current density (J):** The current flowing per unit normal area of cross section is defined as current density. i.e. $J = \dfrac{I}{A}\left(\text{amp}\,\text{m}^{-2}\right)$. Current density is a vector quantity. Its direction is from higher potential to lower potential or its direction is that of the flow of positive charge. $J = nev_d$ where v_d is the drift velocity of electrons.

Circuit
(Closed path for the flow of current)

Open circuit	Close circuit	Short circuit
$R = \infty$ $I = 0$	(Both I & R have certain nominal values)	$R = \infty$ $I = ?$

- *In metallic conductors, the charge carriers are electrons.*
- *In electrolytes, the charge carriers positive and negative ions.*
- In gases, the charge carriers are electrons and positive ions.
- Current is only produced where there is a potential difference
- Due to inelastic collisions of free electrons under the action of potential difference, heat is produced
- A steady current flows when a constant potential difference is maintained.

SOURCE OF CURRENT:

- It converts some kind of energy into electrical current.
- Cells convert chemical energy into electrical energy.

NAME OF DEVICE	NOTABLE FEATURE
Dry Cell	**Most commonly used**
Primary Cell	**Non- rechargeable**
Secondary Cell	**Rechargeable**
Voltaic Cell	**Convert chemical into electrical energy**
Electric Generator	**Convert mechanical into electrical energy**
Solar Cell	**Convert light into electrical energy**
Thermocouple	**Convert heat into electrical energy**

EFFECT OF CURRENT

- *Heating effect i.e.* $H = I^2Rt$ such as in heater.
- *Magnetic effect* such as in transformer, motors etc.
- *Chemical effect* e.g. electroplating.

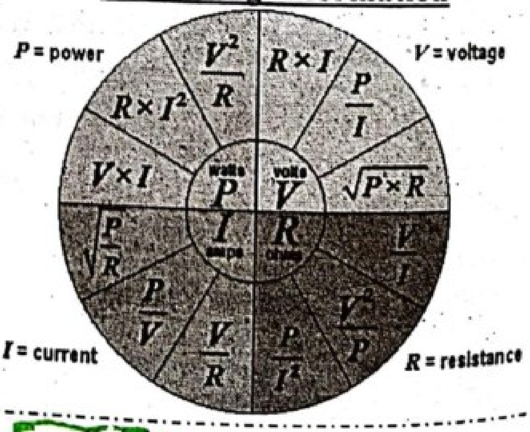
OHM'S LAW

The current flowing through a conductor is directly proportional to the potential difference across its ends provided the physical states such as temperature etc. of the conductor remain constant.

Ohm's law expresses a relation between potential difference and current as given below: $V = IR$

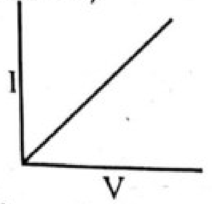
Where R is known as resistance measured in ohms

Interesting Information

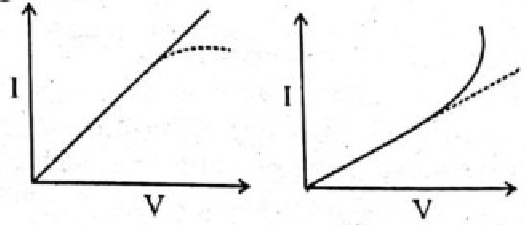


- Microscopic form of Ohm's law is given as; $J = \sigma E$
  Where σ is conductivity

- The metallic conductor that obeys Ohm's law is called ***ohmic conductor***. Its VI graph is a straight line as given below;



- The conductor that does not obey Ohm's law is called ***non-ohmic conductors.*** Its VI graph is not a straight line



For conductor For semiconductor

RESISTANCE, RESISTIVITY & CONDUCTIVITY

Opposition or hindrance to flow of electron is called

Resistance

$$R=\frac{V}{I}$$

Do you know?
Metallic conductors deviate from their ohmic to non-ohmic behavior when subjected to high potential difference.

- *Its SI unit is ohm (Ω)* that is defined as:
  "If 1V potential difference across a conductor produces 1A current then, resistance will be 1Ω."
- Resistance arises due to collision between **current carriers and vibrating** ions.
- Resistance of conductor depends on following factors:
  (i) $R \propto L$ **(ii)** $R \propto 1/A$ **(iii)** $R \propto T$ (except semi-conductors)
  (iv) Nature of material
- Resistivity is a resistance of 1 m cube of a substance. It is given as;
  $$\rho=\frac{RA}{L}$$
  Where ρ is called resistivity
- We can say that,
  $\rho = R$ if $A = 1m^2$, $L = 1m$
  Its SI unit is Ω-m.
- We can say that,
- Reciprocal of resistivity is called *conductivity*
  $$\sigma=\frac{1}{\rho}$$
  Its SI unit is $(\Omega\text{-m})^{-1}$
- R increases with rise of temperature because of increase in amplitudes of vibration of ions the collision chance of electrons against ions increases.
- ***Conductance = 1/Resistance***
  *Its **SI unit** is **mho or siemen**.*

TEMPERATURE CO-EFFICIENT OF RESISTANCE AND RESISTIVITY

- Fractional change in resistance per degree change in temperature is called *temperature co-efficient of resistance*. It is given as;

$$\alpha = \frac{R_t - R_o}{R_o \Delta T} = \frac{\Delta R}{R_o \Delta T} \quad \text{or} \quad R_T = R_o(1 + \alpha \Delta T)$$

- Fractional change in resistivity per degree change in temperature is called **temperature co-efficient of resistivity**

$$\alpha = \frac{\rho_T - \rho_o}{\rho_o \Delta T} = \frac{\Delta \rho}{\rho_o \Delta T} \quad \text{or} \quad \rho_T = \rho_o(1 + \alpha \Delta T)$$

- *SI unit of co-efficient of resistance or resistivity is K^{-1}*
- Temperature co-efficient of conductors is helpful in differentiating them.
- If two conductors (e.g. iron and platinum) have equal resistivity, even then they can be differentiated, by measuring their temperature co-efficient of resistivity.

SUPERCONDUCTIVITY

- When temperature of conductor falls, the amplitude of vibrations of its lattice atoms decreases and hence resistance and resistivity both decrease.
- *It is not possible to make resistance or resistivity equal to zero by falling temperature because ions retain their oscillations even at 0K.*
- Metallic conductors that show remarkable decrease in their resistance with fall of temperature are called *superconductors*.
- The temperature at which a super conductor looses its all resistance is called *critical temperature*. T_c denotes it.
- Major problem with superconductor is that they loose superconductivity at room temperature
- Virtue of superconductivity is to save electrical energy in future
- Electrical energy would pass with zero loss through a super conductor.

For Your Information

- In 1986, Bednortz and Muller discovered some ceramics that show superconductivity at 30K.
- Presently some ceramic materials have been discovered that show super conductivity at 125K

- Superconductivity is a quantum mechanical phenomenon

COMBINATIONS OF RESISTANCES

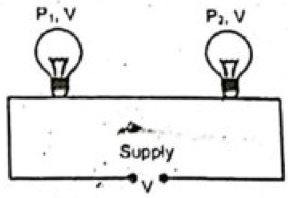
SERIES COMBINATION	PARALLEL COMBINATION
One path for current passage	*More than one paths for flow of current*
Same current through each component	*Different current through each component depending on its resistance*
Different potential difference across each component	*Same potential difference across each component.*
R_{eq} is larger than the largest resistance in the circuit	*R_{eq} is smaller than the smallest resistance in the circuit.*
$R_{eq} = \sum_{i=1}^{n} R_i$	$\frac{1}{R_{eq}} = \sum_{i=1}^{n} \frac{1}{R_i}$

In all combinations of resistors, law of conservation of energy and charge apply.

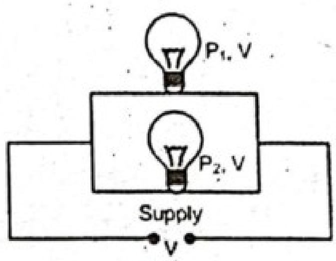
COMBINATION OF BULBS

Bulbs in Series:

- Total power consumed $\frac{1}{P_{total}} = \frac{1}{P_1} + \frac{1}{P_2} + ...$



- If 'n' bulbs are identical, $P_{total} = \frac{P}{n}$
- $P_{consumed}$ (Brightness) $\propto V \propto R \propto \frac{1}{P_{rated}}$ i.e. in series combination bulb of lesser wattage will give more bright light and p.d. appeared across it will be more.



Bulbs in Parallel:

- Total power consumed
- $P_{total} = P_1 + P_2 + P_3 + ... + P_n$
- If 'n' identical bulbs are in parallel $P_{total} = nP$
- $P_{consumed}$ (Brightness) $\propto P_R \propto I \propto 1/R$ i.e. in parallel combination, bulb of greater wattage will give more bright light and more current will pass through it.

Solved example: *Two bulbs are working in parallel order. Bulb A is brighter than bulb B. If R_A and R_B are their resistance respectively then*

(A) $R_A > R_B$ (B) $R_A < R_B$ (C) $R_A = R_B$ (D) None of these

Solution: *(B) In parallel $P_{consumed} \propto$ Brightness $\propto 1/R$*

$P_A > P_B$ (given) $R_A < R_B$

JOULE THOMSON'S EFFECT & POWER DISSIPATION

- When current flows through conductors, then a part of energy of current carriers is transferred to ions on their way, due to which their amplitudes of vibration increases which result in rise of temperature. The above phenomenon is known as *Joule Thomson's effect.* Hence electrical energy is wasted that is given as;

$W = QV$

$P = \frac{W}{t} = \frac{QV}{t}$

$P = IV$

$P = I^2R$

$P = \frac{V^2}{R}$

Where P represents the power dissipation.

- *Heat produced due to power dissipation* is given as;

$H = P \times t$
$= I^2Rt$
$= VIt$
$= V^2t/R$

- If 1J electrical energy is dissipated per second, then power dissipated will be 1 watt.

1 watt = 1J / 1s

- *Kilowatt-hour* is a commercial unit of **electrical energy.** It is defined as: "When a power of 1KW is maintained through a circuit for 1 hour, then energy dissipated is 1KWh."

1 KWh = 1000 W x 3600 sec

= 3.6 x 10^6 J

1 J = 2.77 x 10^{-7} KWh

EMF

emf of a source is defined as potential difference between its out put terminals when either its internal resistance ***is zero or no current is being drawn from it.***

- When charge carriers flow through a conductor, they loose their electrical K.E. In doing work against resistance, loss of energy is compensated by source of **emf at same rate.**
- Every source of emf has its own resistance called ***internal resistance.***
- Smaller is the internal resistance of a battery, better it will be a source of emf
- **Terminal potential** difference is a voltage between out put terminals of a source of emf when current is **drawn from it**.
- We can relate emf (Є), terminal potential (V_t) and internal resistance(r) by the following equation:

$$\frac{\in}{V_t} = \frac{V_t + I_r}{\in - I_r}$$

Point to remember

There are few relations for comparing V_t and E-

(i) $V_t = Є$ if $I = 0$ (open circuit)

(ii) $V_t = Є$ if $r = 0$

(iii) $V_t < Є$ by a factor I r except when one battery charges the other emf is "cause" & potential difference is its "effect". Maximum power is delivered when r = R

KIRCHHOFF'S LAWS

Kirchhoff's Current Law (KCL)

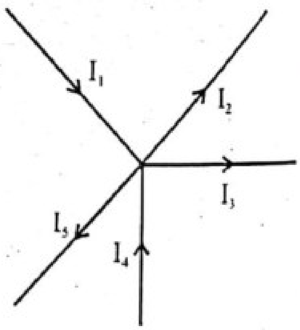
The sum of all the currents flowing towards a point is equal to the sum of all the currents flowing away from the point.

Therefore, $I_1 + I_4 = I_2 + I_3 + I_5$

Hence, $I_1 + I_4 - I_2 - I_3 - I_5 = 0$

Or $\sum I = 0$

(Sum of currents entering a junction = Sum of currents leaving the junction)



This rule is based on the fact that charge cannot be accumulated at any point in a conductor in a steady situation.

Kirchhoff's Voltage Law (KVL)

The algebraic sum of potential changes in a closed circuit is zero.

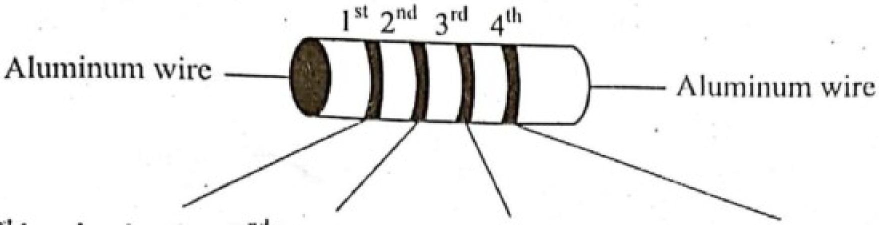
- Loop is a branch of circuit that originates and terminates at the same point.

COLOUR CODE FOR CARBON RESISTORS

B	B	R	O	Y	G	B	V	G	W
0	1	2	3	4	5	6	7	8	9

The resistances are of fixed values but highly temperature dependent.

Method of Designation of Numeric value to a colour coded carbon resistor

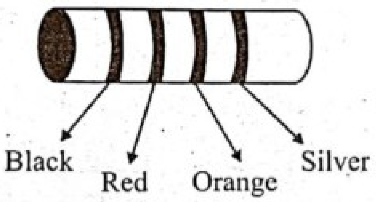


(1st band colour) indicate the 1st digit of the numeric value of resistor.	(2nd band colour) indicate the 2nd digit of the numeric value.	(3rd band colour) indicate the number of zeros in the numeric value.	(4th band colour) specify the tolerance for silver $\pm 10\%$ for gold $\pm 5\%$. no fourth band $\pm 20\%$

Tolerance

By tolerance, we mean the possible variation from the marked value.

For example



The Value of resistance is R = 02 (000) ± (10%) Ω

Tolerance

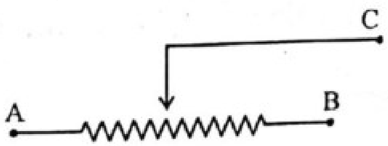
1st digit

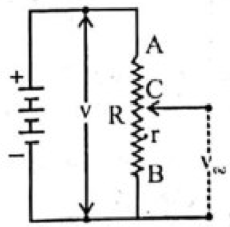
2nd digit

Number of zeros

RHEOSTAT

- t is a wire wound variable resistance consisting of bare maganine wire wound over an insulating cylinder.
- It works on the principle that changes in length effects the value of resistor. $R \times \ell$
  Symbol in electrical circuits is





Use of rheostat as potential divider

- Rheostat is used as a **variable resistance** as well as **potential divider** just like dimmers in electric fans and volume control knob in radio set.

> **Do you know?**
> The thermistors with positive temperature coefficients are also available.

THERMISTORS

Features

- Non-metallic resistors
- Highly heat sensitive resistor
- Negative temperature coefficient of resistance i.e

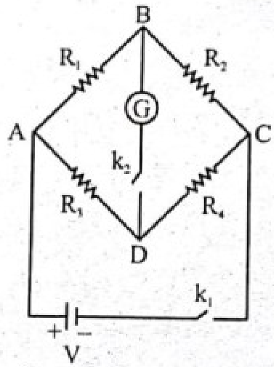
- Resistance decreases with increase of temperature
- Thermistors with positive temperature coefficient are also available

Uses

- For very accurate measurement of very low temperature near about 10K or –263°C.
- As heat sensors because it converts changes of temperature into electrical voltage.

WHEATSTONE BRIDGE (W.S.B)

- W.S.B consists of 4 resistances R_1, R_2, R_3 and R_4 connected in loop or mesh of certain pattern.



- W.S.B is an accurate measuring instrument of resistance up to two decimal place.
- WSB is balanced when its galvanometer shows no deflection even when its keys are closed.
- *Condition for balanced bridge is that current through galvanometer is zero. Voltage across the terminals of the galvanometer will be equal.*

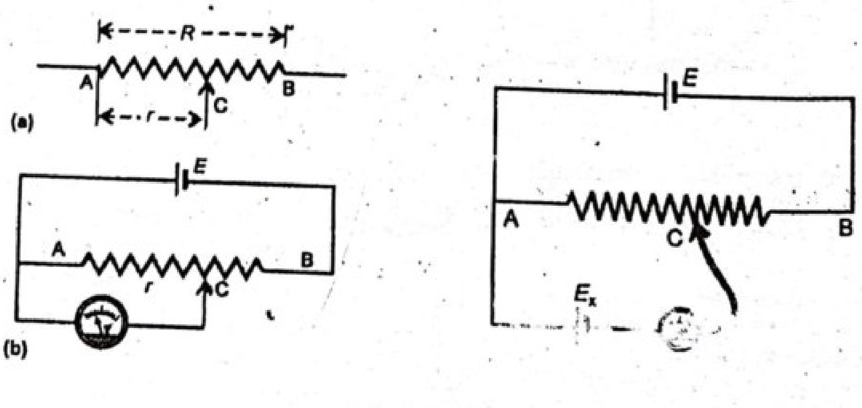
Principle of Whetstone Bridge

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

- Unknown resistance is placed at R_3 or R_4.
- Practical form of Whetstone Bridge is **post office box** and **slide Wire Bridge** that is also called Meter Bridge.

POTENTIOMETER

It is a device which is used to compare and find unknown emf in a circuit without drawing any current from the circuit.



Uses

- Accurate measurement of potential difference
- Measurement of emf of a battery
- Comparing emf's of batteries
- Internal resistance of a cell

- Wire of potentiometer is **4 m long**, made of high resistance wire **(eureka)**

Principle of potentiometer:

*Voltage across any length of a wire of uniform area of cross section is directly proportional to its length when a constant **current flows through** it i.e. $v \propto l$ and current is* ***I = E/R***

- The ratio of the emf of two cells is equal to ratio of the **balancing lengths** i.e.

$$\frac{E_1}{E_2}=\frac{l_1}{l_2}$$

PRACTICE EXERCISE

30 mins Time Yourself

(1) **The current through a metallic conductor is due to the motion of ____________**
(a) free electrons (b) protons
(c) neutrons (d) still under controversy

(2) **Resistance of a conductor depends upon ________________**
(a) charge (b) current
(c) power (d) Temperature

(3) **A car battery is rated at 80A·h. An ampere-hour is a unit of**
Imp
(a) very good conductor (b) moderately good conductor
(c) an insulator (d) no specific criterion available

(4) **A wire of uniform area of cross-section 'A' length 'L' and resistance R is cut into two parts. Resistivity of each part ________________**
(a) remains the same (b) is doubled
(c) is halved (d) becomes zero

(5) **Current is a measure of**
(a) force that moves a charge past a point
(b) amount of charge that moves past a point per unit time
(c) resistance to the movement of a charge past a point
(d) energy used to move a charge past a point

(6) **When same current passes for same time through a thick and thin wire __________**
(a) more heat is produced in thick wire
Imp
(b) more heat is produced in thin wire
(c) no heat is produced in wire
(d] equal heat is produced in thick and thin wire

(7) **When a current of 1A flows for 5 sec through the lamp. How much charge flows through the lamp**
(a) 10C (b) 5C
(c) 1C (d) insufficient data

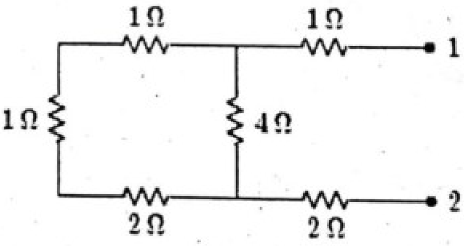
(8) **One kilowatt hour is the amount of energy delivered during ______________**
(a) one second (b) one day
(c) one minute (d) one hour

(9) **Thermocouples convert________________**
(a) heat energy into electrical energy (b) heat energy into light energy
(c) heat energy into mechanical energy (d) mechanical energy into heat energy

(10) **An ordinary light bulb is marked "60W, 120V". Its resistance is:**
(a) 240Ω (b) 180Ω
(c) 200Ω (d) 60Ω

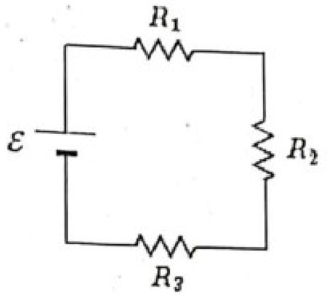
(11) **The equivalent resistance between points 1 and 2 of the circuit shown is:**

Imp



(a) 5Ω (b) 10Ω
(c) 6Ω (d) 3Ω

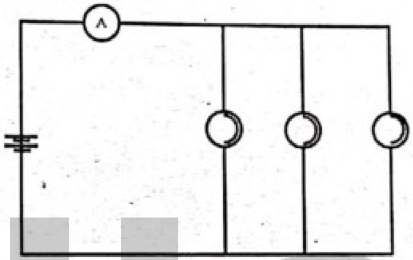
(12) In the diagram $R_1 > R_2 > R_3$. Rank the three resistors according to the current in them, least to greatest



(a)3, 1, 3
(b) 1, 2, 3
(c) All are the same
(d) 3, 2, 1

(13) Three similar light bulbs are connected to a constant – voltage d.c. supply as shown in the diagram. Each bulb operates at normal brightness and the ammeter (of negligible resistance) registers a steady current.

Imp

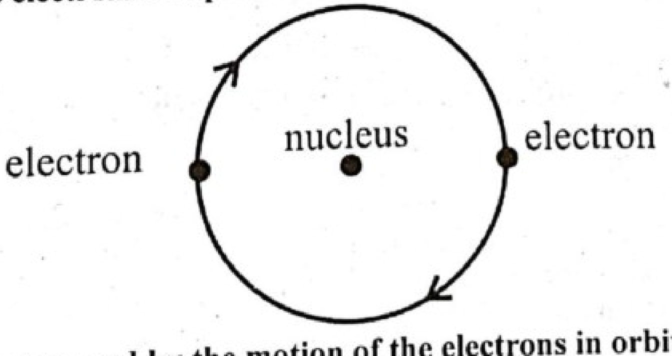


The filament of one of the bulbs beaks. What happens to the ammeter reading and to the brightness of the remaining bulbs?

	Ammeter reading	Bulb brightness
(a)	decreases	unchanged
(b)	Increases	Unchanged
(c)	Unchanged	Unchanged
(d)	increases	unchanged

(14) The diagram shows a model of an atom in which two electrons move round a nucleus in a circular orbit. The electrons complete one full orbit in 1.0×10^{-15} s.

Imp



What is the current caused by the motion of the electrons in orbit?

(a) 1.6×10^{-34}A
(b) 3.2×10^{-34}A
(c) 1.6×10^{-4}A
(d) 3.2×10^{-4}A

(15) Reciprocal of resistivity is called ____________

(a)resistance (b)inductance
(c)conductivity (d)flexibility

(16) When 2Ω, 4Ω and 6Ω resistor are connected in parallel, their resultant equivalent resistance will be____________

(a)12Ω (b)11/12Ω
(c)12/11Ω (d)data is insufficient

(17) Circuit which gives continuously varying potential is called ____________

(a)complex network (b)wheat stone bridge
(c)potential divider (d)all of above

(18) Internal resistance is the resistance offered by ____________

(a)source of e.m.f (b)conductor
(c)resistor (d)capacitor

(19) There are three bulbs of 60W, 100W and 200W which bulb has thickest filament.

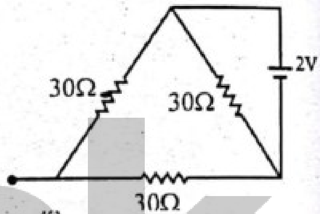
Imp

(a)100W (b)200W
(c)60W (d)all

(20) What can be used as the unit of energy

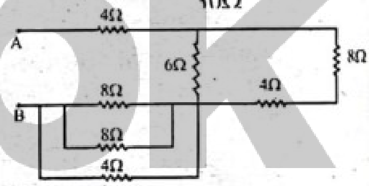
(a)watt x second (b)volt x meter
(c)volt per coulomb (d)Newton per meter

(21) The current in the circuit shown in figure. What will be the current in the circuit?



(a)1/45A (b)1/10A
(c)1/5A (d)5A

(22) Resistance between points A and B in the circuit shown in figure is



(a)4Ω
(b)6Ω
(c)10Ω
(d)8Ω

(23) Two wires made of the same material and of the same length are connected in parallel to the same voltage supply. Wire P has a diameter of 2 mm. Wire Q has a diameter of 1 mm.

Imp

What is the ratio $\frac{\text{current in p}}{\text{current in Q}}$**?**

(A) $\frac{1}{4}$ (b) 4
(c) 2 (d) $\frac{1}{2}$

(24) Resistance of a wire on increasing its temperature will

(a)increase with rise in temperature
(b)decrease with rise in temperature
(c)will remain same
(d)depends upon altitude of experimentation

(25) Specific resistance of a wire

Imp

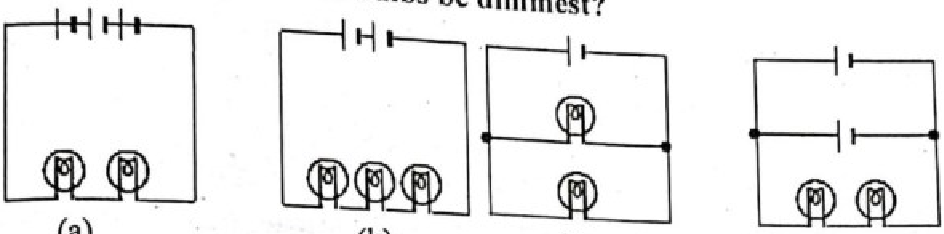
(a)will depend on its length
(b)will depend on its radius
(c)will depend on the type of material of the wire
(d)will depend on none of the above

(26) An electric iron is marked 20 volts 500W. The units consumed by it in using it for 24 hours will be ____________

(a)12 (b)24
(c)5 (d)1100

(27) In the diagrams, all light bulbs are identical and all emf devices are identical. In which circuit (A, B, C, D, E) will the bulbs be dimmest?

Imp



(a) (b) (c) (d)

(28) In liquids and gases, the current is due to the motion ____________

(a)negative charges (b)positive charges
(c)both negative and positive charges (d)neutral particles

(29) A 100W ,200V bulb is connected to a 160V supply. The actual power consumption would be

Imp
(a)64W (b)72W
(c)100W (d)90W

(30) The graphical representation of Ohm's law is ____________

(a)hyperbola (b)ellipse
(c)parabola (d)straight line

(31) SI unit of resistivity is____________

(a)Ω-m^2 (b)$(\Omega\text{-m})^{-1}$
(c)Ω-m (d$(\Omega\text{-m})^{-1}$

(32) The lower part of a cloud has positive. The cloud discharges in flash of lightning, in which direction do electrons and conventional current flow

Imp

	Electron flow	Conventional current
[a]	Downwards	Downwards
[b]	Upwards	Downwards
[c]	downwards	Upwards
[d]	upwards	Upwards

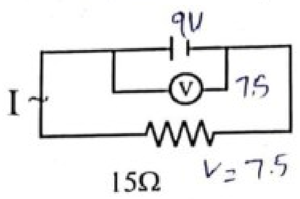
(33) In the diagram, the current in the 3-Ω resistor is 4A. The potential difference between points 1 and 2 is

(a) 20V (b) 0.8V
(c) 12V (d) 1.25V

(34) Why should a resistance be introduced in a circuit in series deliberately?

(a)to increase current (b)to decrease current
(c)to control current (d)just to give a good look to circuit.

(35)



11

V=7.5 I = V/R

The emf of the cell in the following circuit is 9V. The reading on the high resistance voltmeter is 7.5V what is the current I?

Imp
(a) 0.1A (b) 0.6A
(c) 2A (d) 0.5A

(36) What would be the equivalent resistance of a circuit having three resistance of 9Ω each, connected in parallel
(a) 6Ω (b) 27Ω
(c) 3Ω (d) 1Ω

(37) Electrical energy is converted to heat at the rate of ______________
Imp
(a)IRt (b)I^2R
(c)I^2Rt (d)VIt

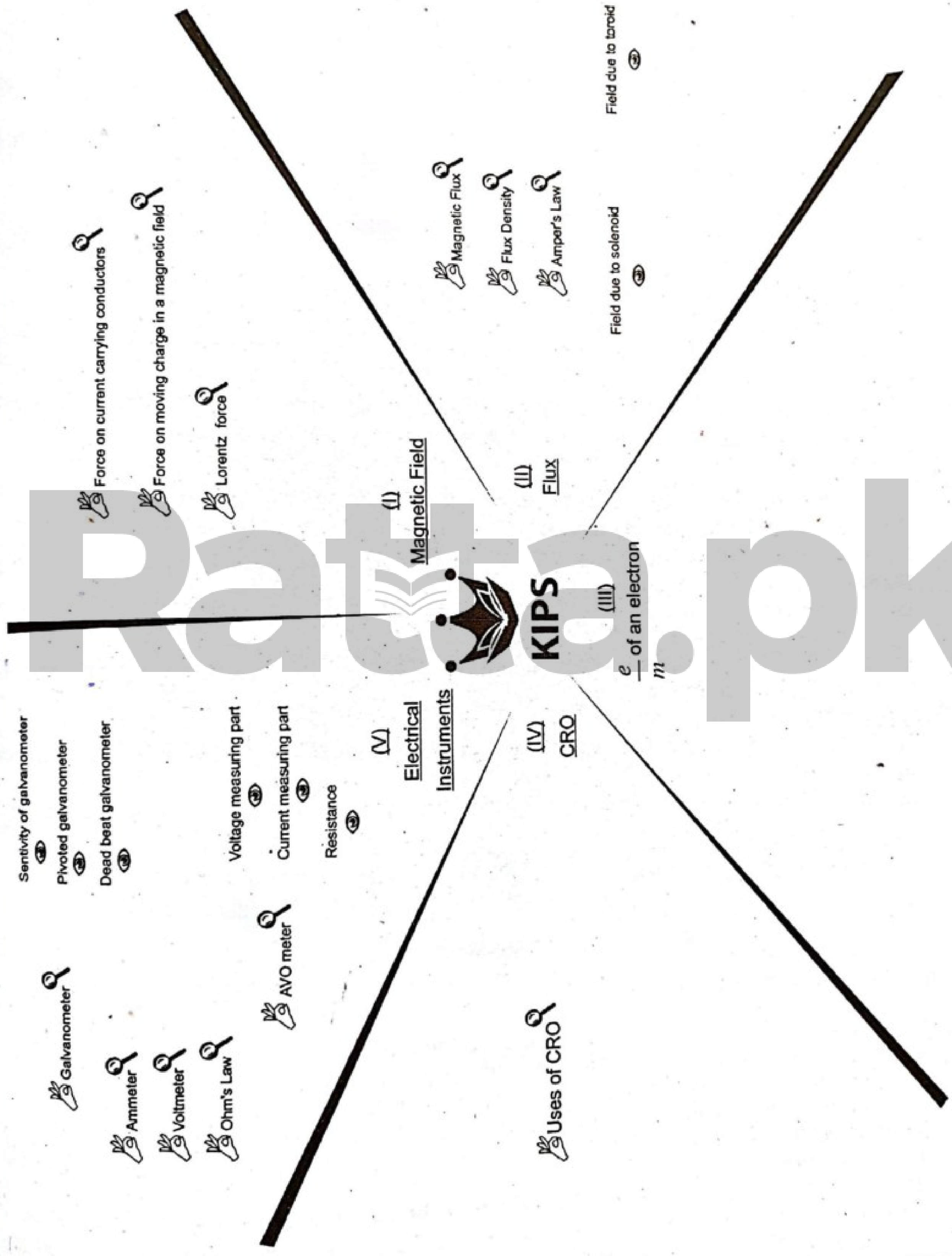
(38) A 20 ohm resistance takes 5 minutes to boil a given amount of water. How much resistance will be required to boil the same amount of water using the same source in 1 minute ?

By ratio

(a)2 ohm (b)5 ohm
(c) 4 ohm (d)3 ohm

(39) A fuse is placed in series with the circuit to protect against ______________
(a)high power (b)high voltage
Imp
(c)high current (d)over heating

(40) If 1 ampere current flows through 2m long conductor, the charge flow through it in 1 hour will be______________
Imp
(a)3600C (b)7200C
(c)1C (d)2C


KIPS
(I) Magnetic Field
Force on current carrying conductors
Force on moving charge in a magnetic field
Lorentz force
(II) Flux
Magnetic Flux
Flux Density
Amper's Law
Field due to solenoid
Field due to toroid
(III) $\frac{e}{m}$ of an electron
(IV) CRO
Uses of CRO
(V) Electrical Instruments
Galvanometer
Sentivity of galvanometer
Pivoted galvanometer
Dead beat galvanometer
Ammeter
Voltmeter
Ohm's Law
AVO meter
Voltage measuring part
Current measuring part
Resistance

INTRODUCTION

- Study of magnetic properties is called *magnetism.*
- Study of magnetic properties associated with electricity and the laws relating to them is called *electromagnetism.*
- Iron ore "magnetite (Fe_3O_4)" was discovered as **early as 600 B.C** from Magnesia, a region in Asia Minor, situated **in modern** Turkey.
- Ore magnet was named **"*LODESTONE*"** meaning leading stone, having directional property.
- Magnetic field arises due to moving electric charge like in atoms or in conducting materials.

CHARACTERISTICS OF A MAGNET

- It has two poles.
- North Pole of magnet coincides with the South Pole of earth's magnet & vice versa.
- Magnetism at poles is greater than at middle.
- Like poles attract while un-like poles repel each other.
- Freely suspended magnet sets itself along N-S direction.

DO YOU KNOW?

Poles of magnet can't be separated i.e. If a large magnet is cut into two parts, each part will be a complete magnet in itself having both N and S poles.

- An un-magnetized magnetic material can be *magnetized* as follows;

(i) By electric method (passing strong D.C)
(ii) By single touch or double touch methods.

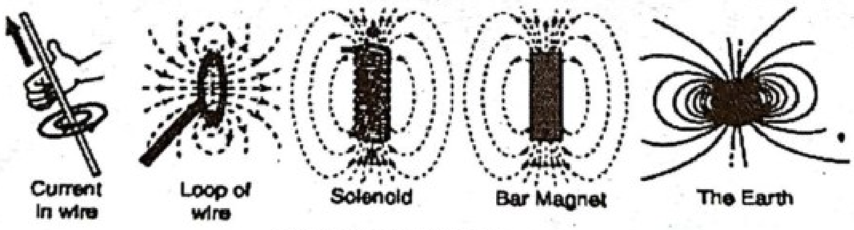
- Magnet can be *demagnetized* as follows;

(i) By passing A.C
(ii) By heating strongly
(iii) By striking a magnet again and again with a surface like that of earth. e.g by hammering with hammer.

MAGNETIC FIELD

Magnetic field is a region around a magnet within which it can exert its influence upon a magnetic material.

- Magnetic field consists of *lines of magnetic force* having following properties:



Magnetic Field Sources

(i) Two magnetic lines of force can't intersect each other.
(ii) Magnetic lines of force fill whole space around a magnet.
(iii) Magnetic lines of force emerge from N-pole and end on S-pole.
(iv) The no. of magnetic lines at a point gives strength of magnetic field.
(v) Longitudinally they tend to shorten their length. It explains attraction between opposite poles.
(vi) Transversely they repel each other. It **explains the repulsion between** two like poles.

- Direction of m*agnetic field of the current is found by right hand rule for* ***positive charges*** *or conventional current.*

Magnetic Field Due to Current in a Long Straight Wire

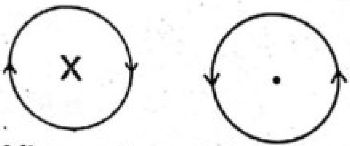
Hans Oersted found that a magnetic field is set up in the region surrounding a current carrying wire.

- The lines of force are circular and their direction depends upon the direction of current.
- The magnetic field lasts only as long as the current is flowing through the wire.

Right Hand Rule

If the wire is grasped in fist of right hand with the thumb pointing in the direction of the conventional current, the fingers of the hand will circle the wire in the direction of the magnetic field

- Following figures should be kept in mind about direction of magnetic field.



I-[Into paper]
B-Clockwise

I [Out of paper]
B-Anti-Clock wise

MAGNETIC FIELD AND MAGNETIC FORCE $(\vec{F}_m)$

Origin of magnetism is motion of charges, was found by ***Oersted.***

Force on a Moving Charge in a Magnetic Field

- In an experiment with bar magnet and field produced by charges flowing in a wire (current), following results are drawn;
  - If $v \parallel B$, then $F_m = 0$
  - If $v \perp B$, then $F_m = \text{max.}$
  - $F_m \perp v$ and $F_m \perp B$
  - $F_m \propto q$
  - $F_m \propto v$
  - $F_m \propto B$
- Single equation containing all above said properties is;

$$\vec{F}_m = q(\vec{v} \times \vec{B})$$

- Magnetic field can be given as;

$$B = \frac{F_m}{qv\sin\theta}$$

So magnetic field strength is defined as "magnetic force acting on a unit charge, entering perpendicularly through a magnetic field with speed of 1 m/s".

- If F_m = 1N, q = 1C, V = 1m/s, then B = 1 Tesla.

$1T = \text{tesla} = \frac{Ns}{Cm} = $ impulse per coulomb per metre. If $\theta = 90°$

So, magnetic field is said to be IT, if 1N force acts on a charged particle carrying 1C charge and entering a magnetic field at a speed of 1m/s perpendicularly.

Force On A Current Carrying Conductor In A Uniform Magnetic Field

- Current carrying conductor experiences a force when placed in a **uniform magnetic field** that is given by; $\vec{F}_m = I(\vec{L} \times \vec{B})$

  Where L is length of conductor inside the magnetic field and defined along the direction of conventional current.
- Drift speed of an electron in a conductor is given as;

$$v_d = \frac{I}{nAe}$$

- Magnetic field can be given as; $B = \frac{F_m}{IL\sin\theta}$

  So, magnetic field is defined as magnetic force acting on a conductor of 1m carrying 1A current and placed ⊥ to magnetic field.
- If F_m = 1N, I = 1A, L=1m & θ = 90°, then B= 1 tesla

  $$1T = \frac{N}{A.m}$$
- Gauss is a small unit of B. **1T = 10^{+4} G**

CURRENT CARRYING COIL PLACED IN A UNIFORM MAGNETIC FIELD

Current carrying coil placed in a uniform magnetic field experiences a torque given by;

$\tau = NIAB\cos\alpha$ *or* $NIAB\sin\theta$

Where N = No. of turns in coil
A = Face area of coil,
∝ = Angle between plane of coil and B
θ = Angle between outward normal to the plane of coil and magnetic field

Note: *Net force on coil is zero but net torque is not zero.*

MAGNETIC FLUX AND MAGNETIC FLUX DENSITY

Magnetic flux is defined as a dot product of magnetic field and area vector of flat surface

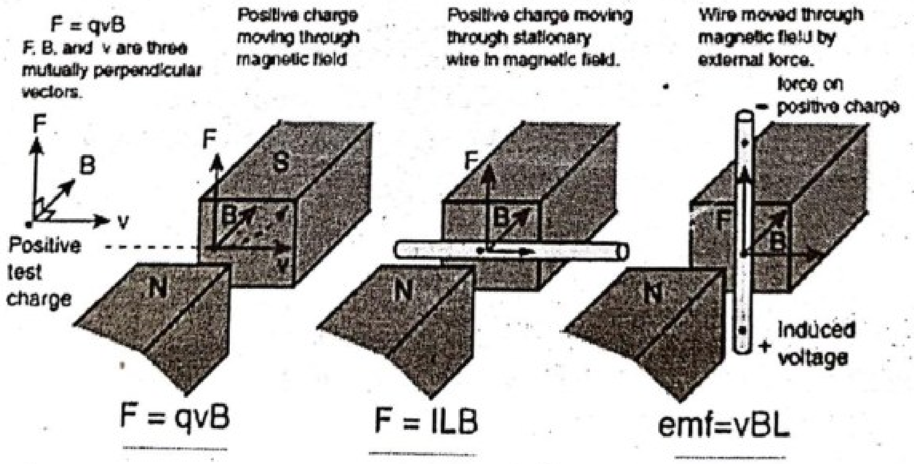
$\phi_m = \vec{A}.\vec{B} = AB\cos\theta$ Or $B = \frac{\phi_m}{A\cos\theta}$

Where B is *magnetic flux density or flux per unit area* normal to the magnetic field lines

- Unit of magnetic flux is weber (Wb).

ϕ_m = 1Wb
if B = 1T
amd A = $1m^2$
and θ = 0^o
1Wb = 1T. $1m^2$
1Wb = 1 NmA^{-1} ∵ $T = NA^{-1}m^{-1}$

For your information



- Ampere's law is used to find the magnetic field strength

AMPERE'S CIRCUITAL LAW

Definition: The sum of the quantities $\vec{B}.\overline{\Delta L}$ for all path elements into which the complete loop has been divided equals μ_o time the current enclosed by the loop. $\sum_{n=r}^{n}\left(\vec{B}.\Delta\vec{l}\right)_r = u_o I$

I = current enclosed by closed path, where $\mu_o = 4\pi \times 10^{-7}$ **Wb/A.m**

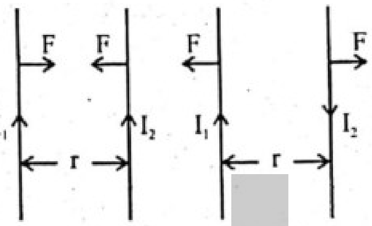
Applications: Field due to solenoid $\mathbf{B=\mu_o n\ I}$

Where n = No. of turns per unit length = $\frac{N}{L}$

Field due to toroid: $\mathbf{B = \mu_o n\ I}$ where $n = \frac{N}{2\pi r}$

$\mu_o = 4\pi \times 10^{-7}\ \frac{Wb}{A.m}$

Magnetic force between two infinitely long parallel current carrying wires: Let us consider two infinitely long parallel straight current carrying conductors placed at distance from each other. Let I_1 and I_2 be the currents flowing in them.



(Attraction) (Repulsion)

Then the force acting per unit length of any wire.

$$F = \frac{\mu_o}{4\pi}\frac{2I_1I_2}{r} = 2\times10^{-7}\frac{I_1I_2}{r}\ \text{Newton/meter}$$

For l meter length of any wire the force

$$F = \frac{\mu_o}{4\pi}\times\frac{2I_1I_2}{r}\times l = 2\times10^{-7}\frac{I_1I_2}{r}\times l\ \text{newton}$$

If the currents are flowing in the same direction, force of attraction exists between the wires and if the currents flow in the opposite direction, force of repulsion exists between the wires Where

POINT TO PONDER

Is it possible that we keep on increasing the number of turns of coil but the magnetic field strength remains constant? Yes. Why?

Field due to toroid

B = μ_on I

Where n= N/2πr

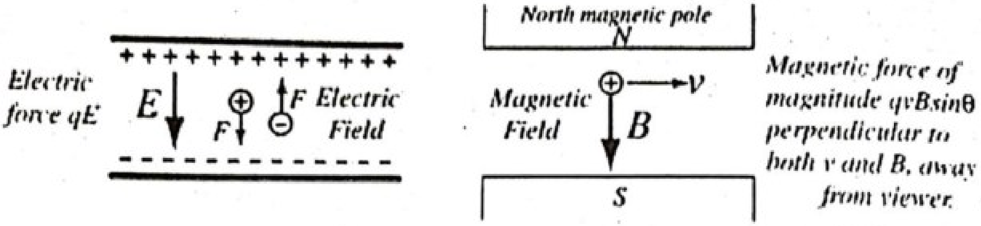
SOLENOID AND TOROID

- *Solenoid* is a cylindrical coil wound on a magnetic or non-magnetic material called core.
- When current flows through a solenoid, the magnetic field is produced inside as well as outside it.
- *Field of solenoid is parallel to its length.*
- *Iron cored solenoid behaves as a bar magnet.*
- *Toroid* is a solenoid **bent into the form of** a circle.
- *Field of* ***toroid is in the form of circular lines*** *of force.*

FORCE ON CHARGE PARTICLE IN AN ELECTRIC AND MAGNETIC FIELD

As,

$\vec{F_e} = q\vec{E}$, and $\vec{F_m} = q\left(\vec{v}\times\vec{B}\right)$ or $\vec{F} = \vec{F_e} + \vec{F_m}$ or $\vec{F} = q\vec{E} + q\left(\vec{v}\times\vec{B}\right)$



Where $\vec{F}$ is called **Lorentz force.**

- Electric force does work
- Magnetic force does no work.

MOTION OF A MOVING CHARGED PARTICLE IN A MAGNETIC FIELD

- *When a narrow beam of electron moving with a constant speed V be projected at right angles to a known uniform magnetic field **B** directed into plane of paper, the electrons experience force at right angle to their direction and they will start moving in a circular path as sown in figure.*

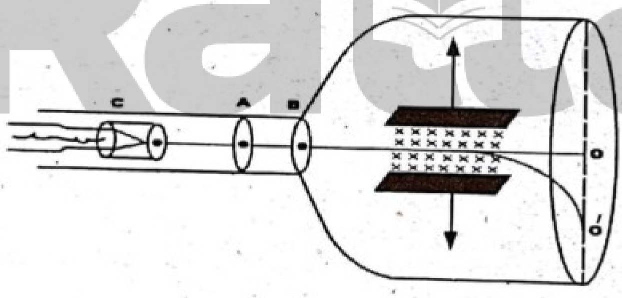
$F_C = F_m$

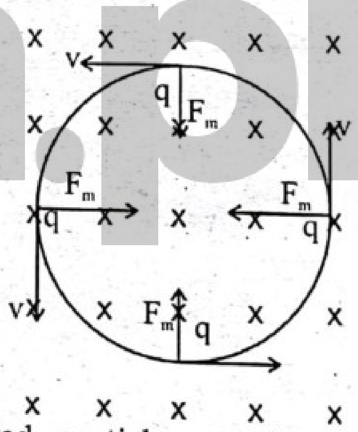
$$\frac{mv^2}{r} = qvB$$

$mv = qBr$

$$r = \frac{mv}{qB} = \frac{p}{qB}$$

p is the momentum of particle





- Magnetic force can do no work on charged particle entering magnetic field because $\mathbf{F_m} \perp \mathbf{V}$ **(always).**
- Time period of charged particle subjected to circular motion in a magnetic field is given as;

  T = circumference /velocity

  $= 2\pi R/v \quad = 2\pi\, mv/qBv$

  $= 2\pi m/qB$
- Frequency of charged particle circulating in a magnetic field is given as;

  $f = 1/T$

  $f = qB/2\pi m$

  It is known as **cyclotron frequency.**

- If a particle has both components of velocity $V_\perp$ and $V_\parallel$ and is allowed to enter a magnetic field B, it **adopts helical motion.**

- Force at 90° to the velocity, changes **direction and not the speed of the particle.**

e/m RATIO

- e/m of a charged particle can be given as; $\frac{e}{m} = \frac{v}{Br}$

  Where R is determined by **Thomson's apparatus** while velocity is determined by following two methods:

POINT TO PONDER 70

The e/m of a proton is greater or less than an electron?

Potential difference method:

$$v = \sqrt{2V_o \frac{e}{m}}$$

So that

$$\frac{e}{m} = \frac{2V_o}{B^2 r^2}$$

Velocity selector method:

$$v = \frac{E}{B}$$

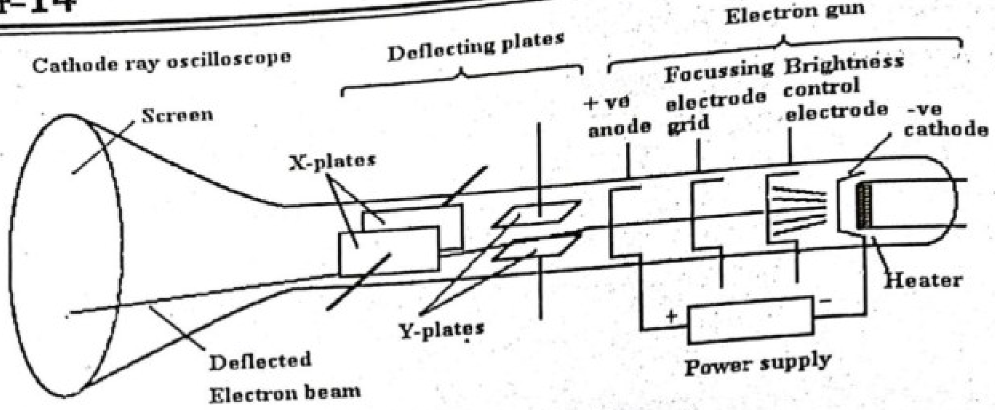
so that $$\frac{e}{m} = \frac{E}{B^2 r}$$

The value of $\frac{e}{m}$ is equal to 1.7588×10^{11} C/kg

CATHODE RAY OSCILLOSCOPE (CRO)

- It is a high-speed graph-plotting device same as **picture tube of T.V** set or monitor of a computer.
- *Electron beam is produced* and deflected by voltage.
- Fluorescent screen make it visible.
- A *grid* is used to control the number of electrons.
- The grid is at a negative potential with respect to cathode.
- *Electrons are accelerated by anode.*
- CRO is used for displaying the waveform of given **voltage.**
- Once the waveform is displayed, we can measure the voltage, its frequency and phase.

Chapter-14



TORQUE

- A current carrying coil placed in magnetic field, will be rotated, in magnetic field, producing torque.

  $\tau = BINA\cos\alpha$

  Where α is the angle made by the **plane** with the **magnetic field**.

  N is the **number of turns** of the coil

  A is the **area of** the **coil.**

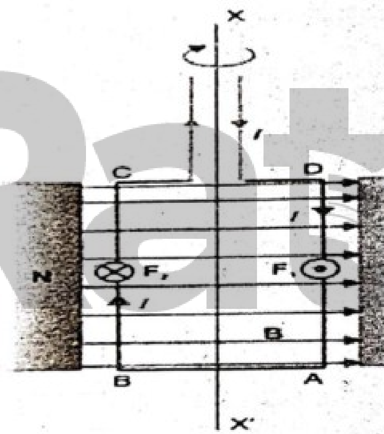
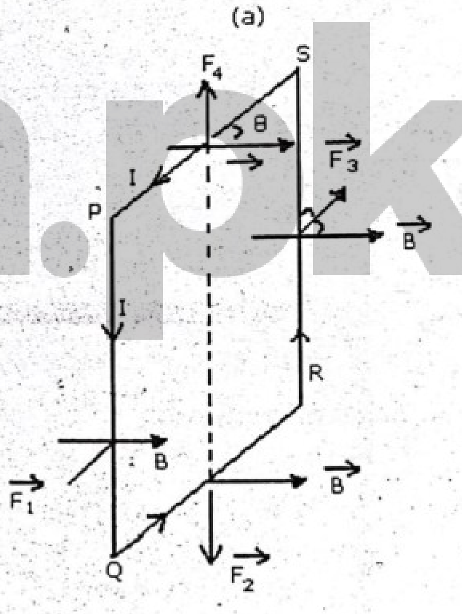
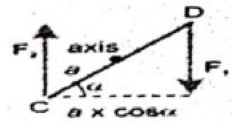


Fig 14.15 (a)





(Top view of coil)
Fig 14.15 (b)

ELECTRICAL MEASURING INSTRUMENTS

Electrical measuring instruments are those devices, which convert **electrical energy into mechanical energy**.

Examples

> **Do you know?**
> All the electrical measuring instruments can only read current because current is the characteristic that can be measured as it can show physical effects. So all measuring instruments show different scales only but they are measuring current e.g. a voltmeter can measure voltage but actually it measures current and display it on the scale of volts.

[i] Galvanometer **[ii]** Voltmeter **[iii]** Ammeter **[iv]** AVO meter

GALVANOMETER (G.M)

Galvanometer is used for the detection of both A.C and D.C currents & voltages.

Principle of G.M

"Current carrying coil experiences electric torque τ=NAIBcosα, when placed in a magnetic field."

- Galvanometer is a parent instrument, which can be converted into voltmeters and ammeters etc.

Types

(i) Moving coil G.M (MCGM)
(ii) Moving magneti G.M (MMGM)

Major parts of moving coil G.M

(i) pole piece made concave
(ii) suspension wire
(iii) lamp-scale arrangement
(iv) coil
(v) hair springs.

- When coil of G.M stops after deflection, then-
  Deflecting torque = Restoring torque
  $I\,N\,A\,B\cos\alpha = c\theta$
  Here $\alpha = 0$,
  $$I = \frac{c\theta}{BAN} = K\theta$$
  Where c represents couple per unit twist or torsion constant that depends upon the nature and **geometry of suspension wire.**
- Galvanometer constant is given as;
  $K = C/BAN$
- A G.M can be made sensitive by making $K = C/BAN$ small.

(i) C is made small by increasing the length and decreasing the diameter of suspension wire
(ii) A, B, N are made large

Note: *Best suggestion is to make* ***B as strong as possible***

Do you know?

The needle of the galvanometer should stop quickly at the mean position, thus should suffer lesser oscillations. So the galvanometers are designed such that these oscillations can be minimized. So they are critically damped. Such type of galvanometer is called dead head galvanometer.

Modifications in Weston-type Galvanometer

i. Suspension wire is replaced by shaft with pivot.
ii. Lamp-scale arrangement is replaced by light aluminum needle and graduated scale.

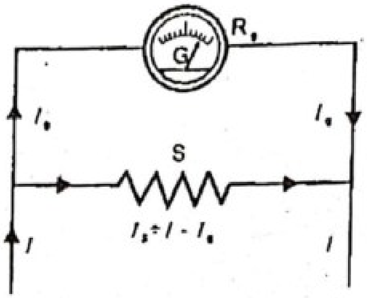
Ammeter

Galvanometer is used for the measurement of current when converted into ammeter.

- G.M can be converted into A.M by connecting a shunt (low resistance) in parallel to its coil.
  Value of shunt is given as;
  $$R_s = \frac{I_g R_g}{I - I_g}$$
  where I is called range.
- To increase the range of A.M, shunt should be made more small
- Range of A.M is given by;

$$= I_g \left[\frac{I + R_g}{R_s}\right]$$

- A.M is always **connected in series.**
- An ammeter must have a very low resistance so that it does not disturb the circuit resistance.



Voltmeter

- Voltmeter is a high resistance G.M.
- To convert G.M into V.M, a high resistance R_h is connected in series with its coil.
- High resistance (multiplier), which converts G.M to V.M is given as;

$$R_h = \frac{V}{I_g} - R_g$$

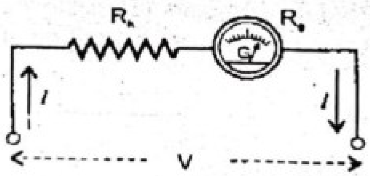
where V is called **range of voltmeter**

- Range of voltmeter is given as;

$$V = I_g (R_g + R_h)$$

It shows that $V \propto R_h$ so making resistance R_h higher can make a V.M **more sensitive**

- Voltmeter is always **connected in parallel.**
- Reading of V.M is not accurate as it draws some current for its working. Hence it measures **less voltage than actual**.
- For accurate measurement of voltage, **potentiometer is used**.



Ohm Meter

- Rapidly measures resistance.
- adjustable resistance along with cell is used internally in ohmmeter. This adjustable resistance is called current limiting resistance

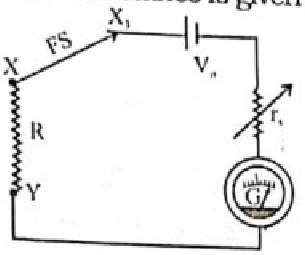
Avo Meter

AVO meter is an electrical measuring instrument used for the measurement of current, voltage and resistance

A for Amp , V for Volt , O for Ohm

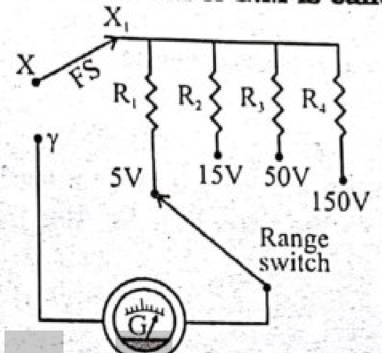
AVO METER AS OHMMETER

- Circuit of AVO meter measurement of resistance is given below:



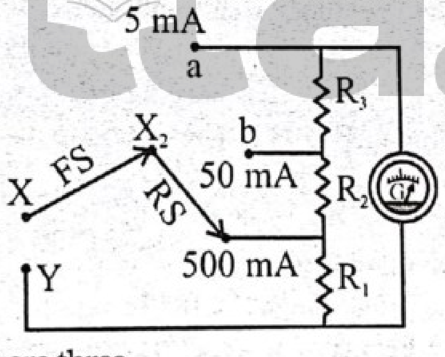
AVO METER AS VOLTMETER

- Circuit of AVO meter for measurement of **voltage is** given below;
- Set of resistance connected in series to coil of **G.M is called multiplier**, as shown below:



AVO METER AS AMMETER

- Set of shunts connected in parallel is called universal shunt or Aryton



- No. of scales on AVO meter are three.

(i) Ohm scale

(ii) Current scale both for A.C & D.C

(iii) Voltage scale both for A.C & D.C

DIGITAL MULTIMETER (DMM)

It is AVO meter but have digital **displaying**.

- It gives decimal counting, polarity and unit for V, A or Ω.
- It is free from human errors of **polarity selection.**

PRACTICE EXERCISE

30 mins Time Yourself

(1) **In the formula $F = q\,(v\times B)$**

(a) F must be perpendicular to v but not necessarily to B

(b) v must be perpendicular to B but not necessarily to F

(c) F must be perpendicular to both v and B

(d) all three vectors must be mutually perpendicular

(2) **A current carrying conductor is placed in a uniform magnetic field parallel to it. The magnetic force experienced by the conductor is__________**

(a)$F=1/B$ (b)$F=1/B\sin\theta$

(c)$F=0$ (d)$F=1/B\cos\theta$

(3) **What is the value of the current in a wire of 10cm length at the right angle to a uniform magnetic field of 0.5 Weber/m^2, when the force acting on the wire is 5N?**

(a)1A (b)10A

(c)100A (d)1000A

(4) **When a particle of charge q and mass m enters a uniform magnetic field B moving with a velocity v perpendicular to the direction for the field, it describes a circular path of radius__________**

(a)$r=qB/mv$ (b)$r=mv/qB$

(c)$r=qmV/B$ (d)$r=qmB/v$

(5) **When a particle of charge q and mass m enters the uniform magnetic field B moving with velocity v perpendicular to the direction of the field, the time required by a charged particle to make a complete revolution in a magnetic field is given by__________**

(a)$T=2\pi q/Bm$ (b)$T=2\pi m/qB$

(c)$T=2\pi B/qm$ (d)$T=qB/2\pi m$

(6) **Two parallel wires carrying currents in the opposite directions__________**

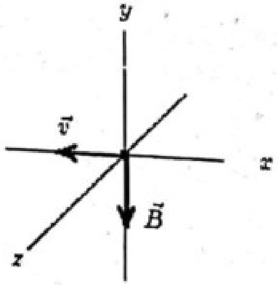
(a)repel each other

(b)attract each other

(c)have no effect upon each other

(d)they cancel out their individual magnetic fields

(7) **An electron moves in the negative x direction, through a uniform magnetic field in the negative y direction. The magnetic force on the electron is**



(a) in the negative z direction (b) in the positive z direction

(c) in the negative y direction (d) n the positive y direction

(8) **An electron is moving north in a region where the magnetic field is south. The magnetic force exerted on the electron is:**

(a) west (b) up

(c) down (d) zero

(9) **A moving coil galvanometer of resistance 100Ω gives half scale deflection for a current of 20mA. What will be the potential difference across it?**

(a) 4 volt
(b) 5 volt
(c) 2 volt
(d) 0.4 volt

(10) **Which one of the following material is most suitable for making core of an electromagnet?**

(a)air
(b)steel
(c)Cu-Ni alloy
(d)soft iron

(11) **The magnetic force experienced by a charge particle moving in a magnetic field will be minimum when it moves __________**

(a)perpendicular to the field
(b)parallel to the field
(c)inclined at some angle to the field
(d)inclined at an angle of 45°

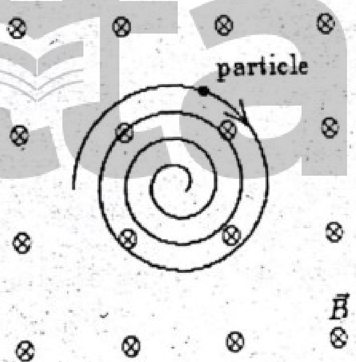
(12) **The relationship between Tesla and smaller unit Gauss of magnetic induction is given by __________**

(a)$1T = 10^3$ G
(b)$1T = 10^{-4}$ G
(c)$1T = 10^{-2}$ G
(d)$1T = 10^4$ G

(13) **If the plane of the rectangular coil is parallel to the magnetic field (i.e. radial magnetic field), the torque on the coil is __________**

(a)τ = NIAB cosα
(b)τ = NIAB sinα
(c) both "a" and "b"
(d)τ = NIAB

(14) **A uniform magnetic field is directed into the page. A charged particle, moving in the plane of the page, follows a clockwise spiral of decreasing radius as shown. A reasonable explanation is**



(a) the charge is negative and slowing down
(b) the charge is positive and slowing down
(c) the charge is positive and speeding up
(d) the charge is negative and speeding up

(15) **Magnetic flux and flux density are related by __________**

(a)magnetic flux = flux density / area
(b)magnetic flux = flux density x area
(c)flux density = magnetic flux area
(d)flux density = magnetic flux × area

(16) **An electron enters a region of uniform perpendicular $\vec{E}$ and $\vec{B}$ fields. It is observed that the velocity $\vec{v}$ of the electron is unelected. A possible explanation is:**

(a) $\vec{v}$ is parallel to $\vec{E}$ and has magnitude E/B
(b) $\vec{v}$ is parallel to
(c) $\vec{v}$ is perpendicular to both $\vec{E}$ and $\vec{B}$ and has magnitude B/E
(d) $\vec{v}$ is perpendicular to both $\vec{E}$ and $\vec{B}$ and has magnitude E/B

(17) The charged particle enters the uniform magnetic field in such a way that its initial velocity is not perpendicular to the field, the orbit will be ________

(a)a circle (b)a spiral

(c)an ellipse (d)a helix

(18) An electron enters a region where the electric field E is perpendicular to the magnetic field B. It will suffer no deflection if__________

(a)E = Bev (b)B = eE/v

(c)E= Bv (d)E = Bev/2

(19) Value of permeability of free space in SI units is ____________

(a)$4\pi x 10^{-9}$ $WbA^{-1}m^{-1}$ (b)$4\pi x 10^{-7}$ $WbA^{-1}m^{-1}$

(c)$4\pi x 10^{-10}$ $WbA^{-1}m^{-1}$ (d)$4\pi x 10^{-8}$ $WbA^{-1}m^{-1}$

(20) The magnetic field strength of a solenoid of turns density $n = \frac{N}{L}$ is

(a) $B = \mu_o NI$ (b) $B = \mu_o N/I$

(c) $B = \mu_o nI$ (d) both (b) and (c)

(21) An instrument, which can measure potential without drawing any current, is ___

(a) voltmeter (b) galvanometer

(c) cathode ray oscilloscope (CRO) (d) ammeter

(22) Electrons (mass m, charge −e) are accelerated from rest through a potential di□erence V and are then deflected by a magnetic field B that is perpendicular to their velocity. The radius of the resulting electron trajectory is

(a) $\frac{\sqrt{2mVe}}{B}$ (b) $\frac{\sqrt{2mV}}{eB}$

(c) $\frac{\sqrt{2mV/e}}{B}$ (d) $\frac{\sqrt{2mVB}}{e}$

(23) When the coil of the galvanometer is in equilibrium, then the deflecting couple is

(a)zero (b)equal to the restoring couple

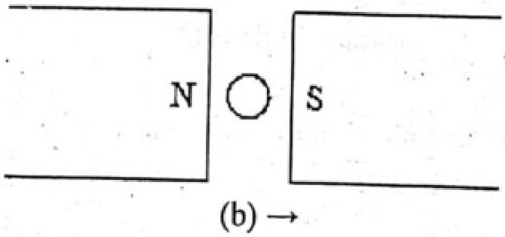
(c)greater than the restoring couple (d)smaller than the restoring couple

(24) The sensitivity of a moving galvanometer is given by

(a) BAN/c (b) cAN/B

(c) c/BAN (d) ABC/c

(25) The diagram shows a straight wire carrying a flow of electrons into the page. The wire is between the poles of a permanent magnet. The direction of the magnetic force exerted on the wire is

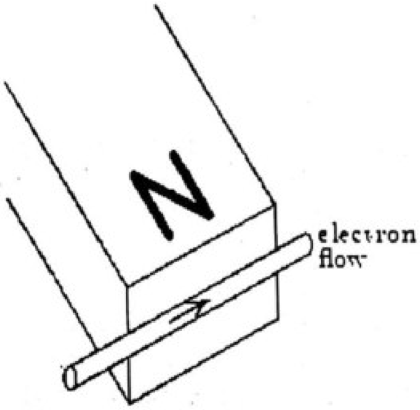


(a) ↓ (b) →

(c) ← (d) ↑

(26) **When charge particle enter a magnetic field then K.E**
(a)remain same
(b)increases
(c)decreases
(d)none of these

(27) **The figure shows the motion of electrons in a wire that is near the N pole of a magnet. The wire will be pushed:**



(a) upwards
(b) away from the magnet
(c) downward
(d) toward the magnet

(28) **The magnitude of force experienced by a stationary charged particle in a uniform magnetic field is**
(a) of $\vec{v}\times\vec{B}$
(b)minimum
(c)zero
(d) maximum

(29) **The magnetic field B inside a long ideal solenoid is independent of:**
(a) the core material
(b) the current
(c) the spacing of the windings
(d) the cross-sectional area of the solenoid

(30) **An ammeter measures the total current flowing through a circuit, when it is connected________________**
(a)in series with the circuit
(b)in parallel with the circuit
(c)in series with any of the parallel resistances in the circuit
(d)in parallel with any of the series resistances in the circuit

(31) **Coil of a galvanometer is suspended in a radial magnetic field so that the deflecting torque on the coil is always____________, (in usual symbols)**
(a)BINA $\cos\alpha$
(b)BINA $\sin\alpha$
(c)BINA $\tan\alpha$
(d)BINA

(32) **A galvanometer basically is an instrument used to ______________**
(a)detect current in a circuit
(b)measure current flowing through a circuit
(c)measure voltage across a circuit
(d)measure potential difference between two points in a circuit

(33) **A solenoid is 3.0cm long and has a radius of 0.50cm. It is wrapped with 500turns of wire carrying a current of 2.0A. The magnetic field at the center of the solenoid is:**
(a) 16T
(b) 9.9×10^{-8} T
(c) 1.3×10^{-3} T
(d) 4.2×10^{-2} T

(34) A wheat stone bridge is said to be balanced when________

(a)maximum current flows through the galvanometer branch

(b)minimum current flows through the galvanometer branch

(c)potential difference across galvanometer branch is maximum

(d)potential difference across galvanometer branch is zero

(35) When an electron moving with a uniform speed in a vacuum enters a magnetic field in a direction perpendicular to the field, the subsequent path of the electron is ________

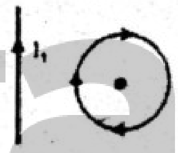
(a) a straight line parallel to the field

(b) a parabola in a plane perpendicular to the field

(c) a circle in a plane perpendicular to the field

(d) a straight line along its initial direction

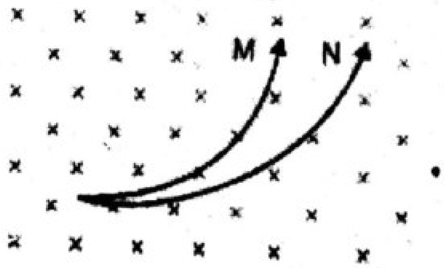
(36) In the given figure, the loop is fixed but straight wire can move. The straight wire will



(a) remain stationary (b) move towards the loop

(c) move away from the loop (d) rotates about the axis

(37) Two charged particles M and N are projected with same velocity in a uniform magnetic field. Then M and N are :



(a) a proton and a-particle respectively

(b) a deuteron and an electron respectively

(c) an electron and a proton respectively

(d) a protium and a proton respectively

(38) • **Concave pole faces of the magnet and soft iron cylinder in galvanometer are used to make the field**

(a) strong (b) weak

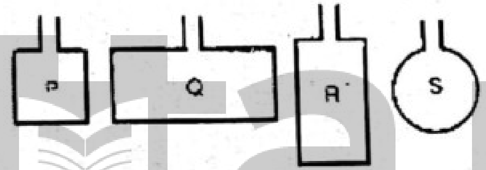
(c) radial (d) radial and stronger

(39) **Heating a magnet will ____________**

(a) weaken it (b) strengthen it

(c) reverse its polarity (d)demagnetize it completely

(40) **Four wires each of length 2 m are bent into four loops P, Q, R and S and then suspended into uniform magnetic field. Same current is passed in each loop. Which statement is correct?**



(a) Couple on loop P will be the highest (b) Couple on loop Q will be the highest

(c) Couple on loop R will be the highest (d) Couple on loop S will be the highest

(I) Induced emf and induced current

- Faraday's Law
- Mutual Induction
- Motional emf
- Self Induction
- Lenz's law
- Energy stored in inductor

(II) Generators

- A.C generators
- D.C generators
- Back motor effect

(III) Motors

- A.C motors
- D.C motors
- Back emf effect in motor

(IV) Transformers

- Step – up transformer
- Step – down transformer
- Power transmission
- Efficiency
- Hysterisis loss

KIPS

- ***Orested*** *discovered magnetic field* due to current carrying coil.
- ***Faraday*** *discovered electromagnetic induction* (production of induced emf and induced current by the time rate of change of magnetic flux $\phi = BA\cos\theta$
- The induced current depends upon the speed with which the conductor moves and upon the resistance of the loop.
- The induced current can be increased by-
  - Using a stronger magnetic field
  - Moving the loop faster
  - Replacing the loop by a coil of many turns

Point to Remember

As magnetic flux is

$\Phi_m = BA\cos\theta$

So the change in flux can be caused as:-

- Change in magnetic field strength.
- Change in projected area.
- Possible change in the orientation of coil in field.

FARADAY'S LAW

First law

Induced emf lasts till the **flux remains changing.**

Second law

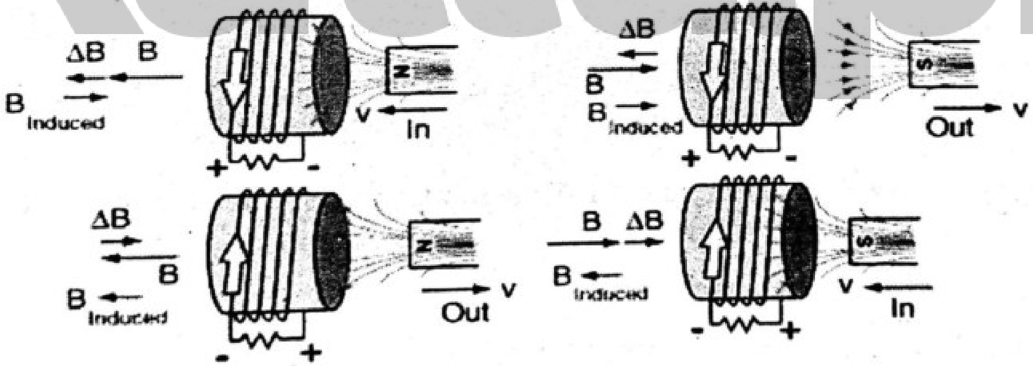
Induced emf is directly proportional to the time rate of change of magnetic flux i.e.

$$\epsilon = -N\frac{\Delta\varphi_m}{\Delta t}$$

- Direction of induced e.m.f is given by ***Lenz's law***, which states:

  "e.m.f is induced in such a way that it opposes its own Cause of ***generation****"*

- Lenz's law is in accordance with the law of conservation of energy.



- The mechanism of generation of induced e.m.f is such that energy fed to change flux, changes to magnetic force, which moves free electrons to cause the current and **hence induced e.m.f.**
- Following ways can change magnetic flux (or in other words, can produce induced e.m.f): -
  - Motion of magnet.
  - Motion of coil.
  - Relative motion of coil and magnet.
  - Change of current.
- If there does not exist Lenz's law then perpetual motion machine of 1st kind was possible. Thus the process will be self-perpetuating.

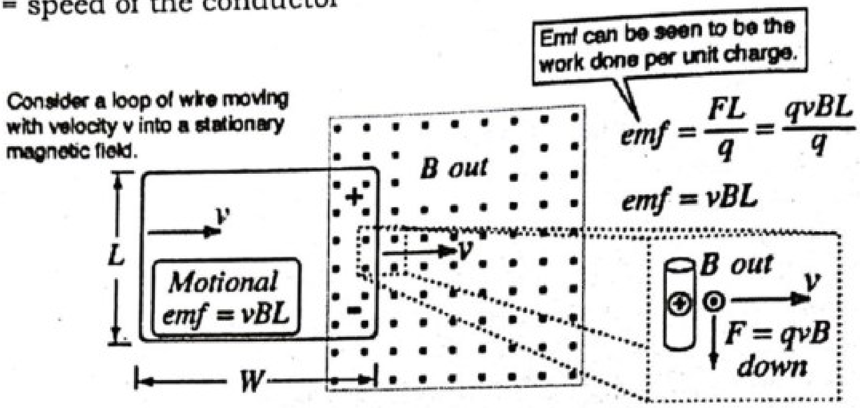
Chapter-15

MOTIONAL emf

The emf induced by the motion of a conductor across a magnetic field is called motional emf.

$$\epsilon_{(motional)} = -vBL$$

where v = speed of the conductor L = length of the conductor



- If there is some orientation of the coil to the magnetic field, then
  $\epsilon_{(motional)} = -vBL\sin\theta$
  where θ is the angle between v & B.
- *The unit of motional emf is volt.*
- *Magnetic field strength is considered to be uniform while deriving the above expression.*

MUTUAL INDUCTION & SELF INDUCTION

- *Mutual induction* is a phenomenon in which a changing current in one **(primary)** coil induces an emf in another coil **(secondary)**
  $e.m.f_{sec} = -M\ \Delta I_P/\Delta t$
  Where $M = N_s\Phi_s/I_p$ called mutual inductance.
- Mutual inductance is defined as the ratio of back e.m.f in the secondary to the rate of change of current in primary coil.

$$M = \frac{-emf}{\Delta I_P/\Delta t}$$

- ***Self-induction*** is a phenomenon of generation of induced e.m.f in a coil due to change of current in itself.

$$e.m.f_{self} = -L\frac{\Delta I}{\Delta t}$$

where L is called self inductance. Also $\mathbf{N\Phi = LI}$

- Self-inductance is defined as the ratio of back e.m.f to rate of change of current in the same coil.

$$L = \frac{-emf_{self}}{\Delta I/\Delta t}$$

- *SI unit of mutual and self inductance is Henry (H).*

(i) $M = 1\ H$ if $e.m.f_{sec} = 1V$ and $\Delta I_P/\Delta t = 1A/s$
Mutual inductance is said to be 1 H if a current change in primary at a rate of $1As^{-1}$ produces e.m.f of 1 volt in secondary.

(ii) $L = 1\ H$ if $e.m.f = 1V$ and $\Delta I/\Delta t = 1\ A\ s^{-1}$
Self-inductance is said to be 1H, if **current changing at the rate of 1 A/sec produces an e.m.f of 1V in the coil itself.**

ENERGY STORED IN AN INDUCTOR

Inductor is simply an insulated coil that **offers very small resistance** to D.C current but offers **high resistance to A.C current.**

- In case of capacitor, energy is stored in electric field between the plates. Similarly, energy is stored in magnetic **field of the inductor.**
- Work done by the battery to move charges **against the induced emf** is $W = \frac{1}{2} LI^2$
- This work is stored as potential energy in the inductor as $U_m = \frac{1}{2} LI^2$

Also $L = \mu_o n^2 A l$

$$U_m = \frac{1}{2}\left(\mu_o n^2 A l\right) I^2$$

As $B = \mu_o n I$

Then $U_m = \frac{1}{2} B^2 \frac{Al}{\mu_o}$

As $Al = \text{Volume}$

Then energy density is $U = \frac{U_m}{Al} = \frac{1B^2}{2\mu_o}$

or $U = \frac{1}{2}\frac{B^2}{\mu_o} \Rightarrow U \propto B^2$

- Inductor in an A.C circuit always resists the abrupt change in current.

Do you know?

The density of energy storage in an inductor is directly proportional to the square of the magnetic field strength provided all other factors remains constant.

SERIES AND PARALLEL COMBINATION OF INDUCTANCES

Coils in series: If two coils of inductance L_1 and L_2 are connected in series then

$$\varepsilon = \varepsilon_1 + \varepsilon_2 \quad \text{or} \quad L_s \frac{\Delta I}{\Delta t} = L_1 \frac{\Delta I_1}{\Delta t} + L_2 \frac{\Delta I_2}{\Delta t} \qquad \left[\text{as } \varepsilon = -\frac{L\Delta I}{\Delta t}\right]$$

However in series as current remains same $I = I_1 = I_2$ or $\frac{\Delta I}{\Delta t} = \frac{\Delta I_1}{\Delta t} = \frac{\Delta I_2}{\Delta t}$

Therefore $\mathbf{L_s = L_1 + L_2}$

Coils in parallel: As in case of parallel combination of coils, the current divides, i.e.

$$I = I_1 + I_2 \quad \text{or} \quad \frac{\Delta I}{\Delta t} = \frac{\Delta I_1}{\Delta t} + \frac{\Delta I_2}{\Delta t}$$

$$\frac{\varepsilon}{L_p} = \frac{\varepsilon_1}{L_1} + \frac{\varepsilon_2}{L_2} \qquad \left[\text{as} \quad \varepsilon = -L\frac{\Delta I}{\Delta t} \text{ i.e., } \frac{\Delta I}{\Delta t} = -\frac{\varepsilon}{L}\right]$$

However, in parallel, as potential same, i.e., $\varepsilon = \varepsilon_1 = \varepsilon_2$

Therefore $\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2}$ i.e., $L_p = \frac{L_1 L_2}{L_1 + L_2}$

A.C & D.C GENERATOR

Current generator is a device, which converts mechanical energy into **electrical energy in the presence of magnetic field.**

- The principle of generator is that emf is induced across a coil rotating in a magnetic field due to change of **magnetic flux.**
- Main parts of A.C generator
  - Pole pieces (U-shape magnet) with concave poles.
  - Armature (assembly of coil on iron cylinder)
  - Slip rings (as connector)
  - Carbon brush (external supply)
- emf is induced by the side of loop intersecting the **magnetic** field.
- Total emf for N number of loops is given as;

$\varepsilon = N(2vB\ell \sin\theta)$ also $\varepsilon = N\omega AB \sin\omega t$

$\varepsilon_{max} = N\omega AB$ when $\theta = 90^\circ$

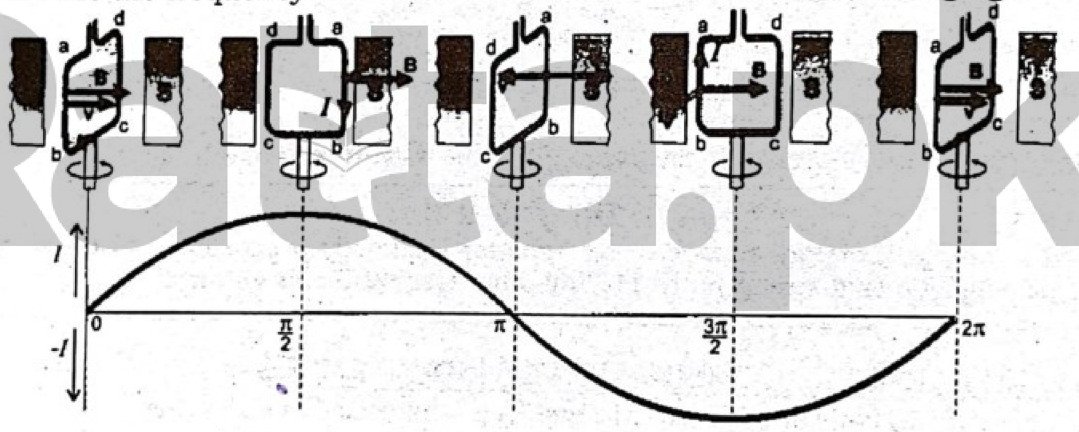
then $\varepsilon = \varepsilon_{max} \sin\omega t$ If $\omega = 2\pi f$, then

$\varepsilon = \varepsilon_{max} \sin 2\pi ft$

In terms of potential difference, $\mathbf{V = V_o \sin 2\pi ft}$

In terms of current, $\mathbf{I = I_o \sin 2\pi ft.}$

where f is the frequency with which the direction of current is changing.



- In Pakistan f = 50Hz, it means 50 times in a second direction is changing.
- In D.C generator **split rings or commutators, invented by William Sturgeon** are used in place of slip rings.
- D.C generator produce uni directional pulsating D.C, not pure D.C
- For pure D.C many coils are wound around cylindrical core

BACK MOTOR EFFECT IN GENERATOR

- The device in electric circuit that consumes electric energy (electricity) is known as **load.**
- The greater the load, the larger the current is supplied by the generator (indicated by sound of generator)
- "When the circuit is closed, a current is drawn through the coil. The magnetic field exerts force on the current carrying coil. This force produces a counter torque that opposes the rotational motion of the coil. This effect is called **back motor effect of generators.**"
- According to energy conservation law, the energy consumed by the load must come from the energy source used to **drive turbines.**

- The larger the current drawn by the load, the greater is the **counter torque produced.**

D.C MOTORS

- A motor is a device which converts **electrical energy** into **mechanical energy.**
- A generator running backward is called motor.
- Principle of motor is that whenever a current carrying coil is placed in a magnetic field it experiences a couple of forces, which causes torque.

BACK E.M.F EFFECT IN MOTORS

- The self induced emf (ε) in a motor opposes the voltage v **running the motor**. This induced emf is called the **back emf of motor.**
- The magnitude of the back emf increases with the speed of motor.
- V & ϵ are in opposite polarity.

  i.e. current flowing in motor is

$$I = \frac{(V - \varepsilon)}{R} \quad \text{or} \quad V = \varepsilon + IR$$

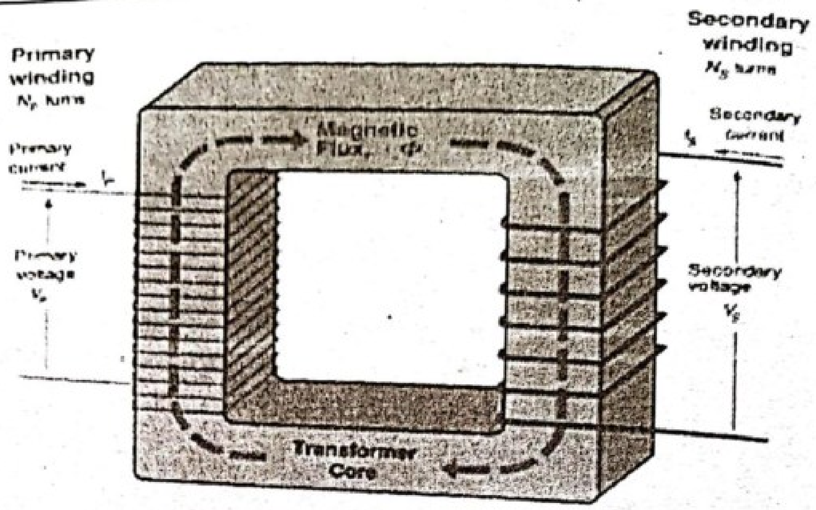
- As the motor speeds up, the back emf increases and the **current** becomes smaller and smaller. So current should be kept sufficient to provide torque.
- If motor is overloaded, the back emf decreases and allow the motor to draw more current
- If motor is overloaded beyond its limits, the current could be so high that it may **burn** the motor coil.

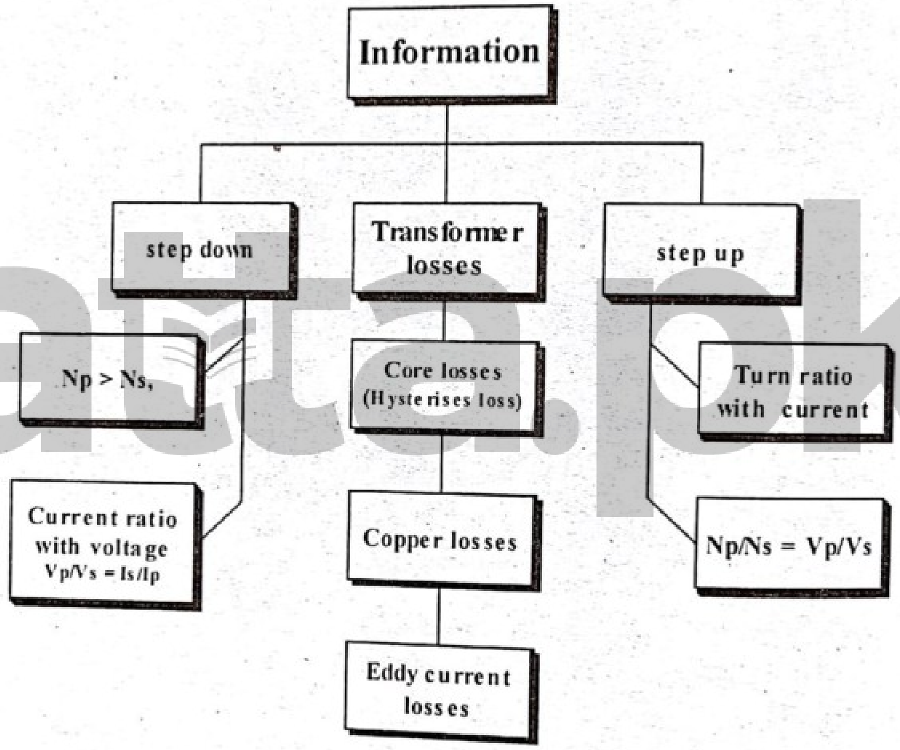
> **Do you know?**
> Transformer is one of the static devices in the electrical appliances. So there is no loss of energy in friction. Hence they can have higher efficiencies. We can achieve up to 95% efficient transformer

TRANSFORMER

Transformer is an electromagnetic device used to step up or step down A.C voltage or A.C current, not D.C.

- Principle of transformer is **the mutual induction.**
- Coil of transformer where input is applied is called **primary** coil while other where out put is obtained is called **secondary coil.**
- Core consist of laminated punched sheets of soft iron on which coil is wound.
- Lamination of core is done to reduce **eddy current losses** (eddy current is an induced current produced in a core).





- Transformer can't step up or step down the **energy or power.**
- Transformer consumes very litter part of input power so it can be kept running for hours without considerable loss of power.

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$$

Losses in actual transformer: The losses in transformer occur in core and winding.

Types of Losses in transformer:

- **Copper Losses in winding:** Due to resistance of the windings of primary and secondary coils, some electrical energy is always lost in the form of heat energy.
- **Flux losses:** The coupling of the primary and secondary is never perfect and whole of the magnetic flux produced in the primary coil does not link the secondary coil. This results in some energy loss.

- **Iron losses in core:** Iron losses are of two types: Eddy current loss and hysterisis loss

(i) **Eddy current loss:** Due to the periodically varying nature of A.C. supplied in primary, the flux associated with core changes and, therefore, eddy currents are induced in it.

Eddy currents induced in the core are undesirable as they heat the core and result in energy loss. To minimize the eddy current losses, core is laminated.

(ii) **Hysterisis loss:** The alternating current flowing through the coils magnetizes and demagnetizes the iron core again and again. Therefore, during each cycle of magnetization, some energy is lost due to hysterisis. To minimize this loss we choose material of core of smaller hysterisis loss generally soft iron.

Efficiency of transformer: Ideal transformer, efficiency is 100 % or 1. but in actual transformer output power is always less than input power, so efficiency also always less than 100%. In general efficiency of transformer is very high (and is of the order of 90%).

Efficiency is given by $\eta = \frac{\text{Output power}}{\text{Input power}} \times 100$. In terms of secondary and primary voltages and currents, $\eta = \frac{V_s I_s}{V_p I_p}$. Also since, **Input = Output + Losses,**

so $\eta = \frac{\text{Output power}}{\text{output power} + \text{Losses}}$

Applications:

- They are used in power distribution in a safe manner from power stations to the utility stations.
- The principle of transmission is that we reduce the value of current via increasing the transmission voltage so saving the cost of copper as less thick wire can full fill the purpose due to small currents.
- Transformers also provide a degree of control of electricity distribution to a town.

PRACTICE EXERCISE

30 mins
Time Yourself

(1) **The practical illustration of the phenomenon of mutual induction is________**

(a)A.C generator (b)D.C dynamo
(c)motor (d)transformer

(2) **Faraday's law states that an induced emf is proportional to:**

(a) the rate of change of the magnetic field
(b) the rate of change of the electric field
(c) the rate of change of the magnetic flux
(d) the rate of change of the electric flux

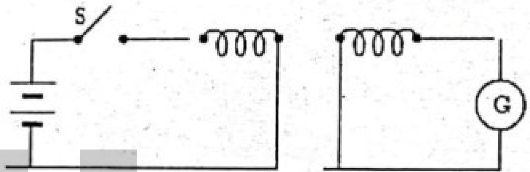
(3) **Current produced by moving the loop of wire across a magnetic field is called ____**

(a)A.C current (b)D.C current
(c)induced current (d)mean square current

(4) **emf induced in a circuit according to Faraday's law depends on the ________**

(a) maximum magnetic flux (b) rate of change of magnetic flux
(c) change in magnetic flux (d) None of these

(5) **For the experiment shown below**



Imp

(a) there is a steady reading in G as long as S is closed
(b) a motional emf is generated when S is closed
(c) the current in the battery goes through G
(d) there is a current in G just after S is opened or closed

(6) **An alternating current or voltage ______________**

(a)fluctuates off and on
(b)varies in magnitude alone
(c)changes its direction again and again
(d)changes its magnitude continuously and reverses its direction of flow after regularly recurring intervals.

(7) **A dynamo converts ____________**

(a) mechanical energy into electrical energy
(b) electrical energy into mechanical energy
(c) magnetic energy into electrical energy
(d) all of these

(8) **Which one of the following functions, like a motor?**

(a)galvanometer (b)ammeter
(c)voltmeter (d)all of above

(9) **The emf developed in a coil X due to the current in a neighboring coil Y is proportional to the:**

Imp

(a) thickness of the wire in X (b) resistance of X
(c) rate of change of magnetic field in X (d) magnetic field in X

(10) **Which of the following works on torque on the current carrying conductor placed in magnetic field.**

(a)galvanometer (b)ammeter
(c)voltmeter (d)all of the above

(11) Self inductance of a coil depends upon ________

(a)current flowing
(b)number of turns per unit length
(c)voltage produced
(d)all

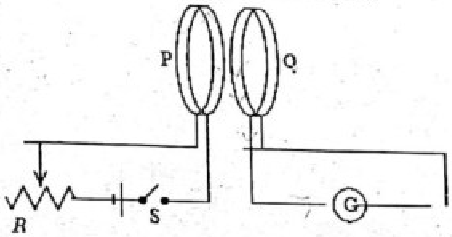
(12) If the coil is wound on an iron core, the flux through it will________

(a)decrease
(b)become zero
(c)remain the same
(d)increase

(13) Energy stored in a magnetic field is given by ________

(a)LI^2
(b)$\frac{1}{2}L^2I$
(c)$\frac{1}{2}LI^2$
(d)IL^2

(14) Coils P and Q each have a large number of turns of insulated wire. When switch S is closed, the pointer of galvanometer G is deflected toward the left. With S now closed, to make the pointer of G deflect toward the right one could



(a) move coil P toward coil Q
(b) open S
(c) move coil Q toward coil P
(d) move the slide of the rheostat R quickly to the right

(15) A long narrow solenoid has length and a total of N turns, each of which has cross-sectional area A. Its inductance is

(a) $\frac{\mu_0 N^2 A}{l}$ L=
(b) $\frac{\mu_0 N A}{l}$
(c) $\frac{\mu_0 N^2 l}{A}$
(d) $\frac{\mu_0 N^3 A}{l}$

$N\phi = LI$
$\frac{N \times BA}{I}$
$\frac{N \times \mu_0 n I A}{I}$
$\frac{N^2}{l}\mu_0 A$

(16) Which of the following uses electric energy and does not convert it into any other form?

(a)transformer
(b)motor
(c)D.C generator
(d)A.C generator

(17) The only difference between construction of D.C generator and A.C generator is that of________

(a)carbon brushes
(b)coil
(c)commutator
(d)magnetic field

(18) The stored energy in an inductor:

(a) depends on the rate of change of current — Change
(b) is proportional to the square of the inductance
(c) has units J/H
(d) none of the above

Chapter-15

(19) If the secondary coil has N_s turns and the primary N_p turns, the relation between secondary and primary voltages is given by ________

(a) $V_s/V_p=N_p/N_s$
(b) $V_s/V_p = N_s/N_p$
(c) $V_p/V_s=N_s/N_p$
(d) $V_p/V_s=N_pN_s$

(20) Power loss in actual transformer is due to________

(a) Small output
(b) Eddy currents and magnetic hysterises
(c) Soft iron core
(d) Back emf

(21) A magnet is allowed to fall through a copper circular wire. Then during fall:

Imp

(a) the electric current flows through the wire
(b) the acceleration of magnet is less than gravitational acceleration
(c) the acceleration of magnet is equal to gravitational acceleration
(d) both A and B

(22) The emf induced in a coil by a changing magnetic flux may have unit as

(a) $ms^{-1}A$
(b) $ms^{-2}A^{-1}$
(c) $kgms^2A^{-1}$
(d) $kgm^2s^{-3}A^{-1}$

(23) A coil of wire is arranged with its plane perpendicular to a uniform magnetic field of flux density B. when the radius of the coil increases from r_1 to r_2 in time Δt, then what is the emf induced in the coil?

(a) $\frac{\pi B\left(r_2^2-r_1^2\right)}{\Delta t}$
(b) $\frac{\pi B\left(r_2-r_1\right)^2}{\Delta t}$
(c) $\frac{B\left(r_2^2-r_1^2\right)}{\Delta t}$
(d) $\frac{\pi B\left(r_2^2+r_1^2\right)}{\Delta t}$

(24) The emf induced in a conductor of unit length moving with unit velocity at right angles to a magnetic field is equal to

Imp

(a) Magnetic flux density
(b) Torque
(c) Mutual induction
(d) Motional emf

(25) A step up transformer has transformation ratio of 3:2. what is the voltage in secondary if the primary voltage is 30V.

(a) 20V
(b) 60V
(c) 45V
(d) 15V

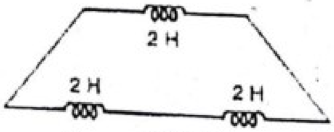
(26) Eddy currents are produced in a material when it is

(a) Heated
(b) Placed in a time varying magnetic field
(c) Placed in an electric field
(d) Placed in a uniform magnetic field

(27) In an electromagnetic wave the electric field vector E and the magnetic field vector B are

(a) Perpendicular to each other
(b) Parallel to each other
(c) 45^o to each other
(d) Can have any angle between them

(28) Three pure inductors each of 2 H are connected as shown in the figure. The equivalent inductance of the circuit is



$\frac{1}{4}+\frac{1}{2}$

$\frac{3}{4}$ H = $\frac{4}{3}$ H

(a) 6 H
(b) 2H
(c) 8/6 H
(d) 3/4H

(29) **In a step up transformer the number of turns in**
(a) primary are less
(b) primary are more
(c) primary and secondary are equal
(d) primary are infinite

(30) **The transformer is used to light a 500 W and 220 V lamp from 220 V mains. If the main current is 0.5 amp, the efficiency of the transformer is**
(a) 11%
(b) 390%
(c) 550%
(d) 455%

(31) **The alternating current has frequency of 10^6 Hz, in such a way that time period for completion of cycle is**
(a) 1μs
(b) 1.5μs
(c) 10^6sec
(d) 1sec

(32) **Which of the following quantitative remain same in the transformer**
(a) current
(b) frequency
(c) voltage
(d) all of these

(33) **Which one of the following devices does not function like an electric motor?**
(a) Galvanometer
(b) Ammeter
(c) Voltmeter
(d) Transformer

(34) **The out put voltage of a transformer is 3 times the input voltage then turns ratio will be________**
(a) 1/3
(b) 3
(c) 1
(d) 6

(35) **For long distance transmission, the transformer used is**
(a) Step down
(b) Input voltage and output voltage remain same
(c) Step up
(d) Amplifier is used

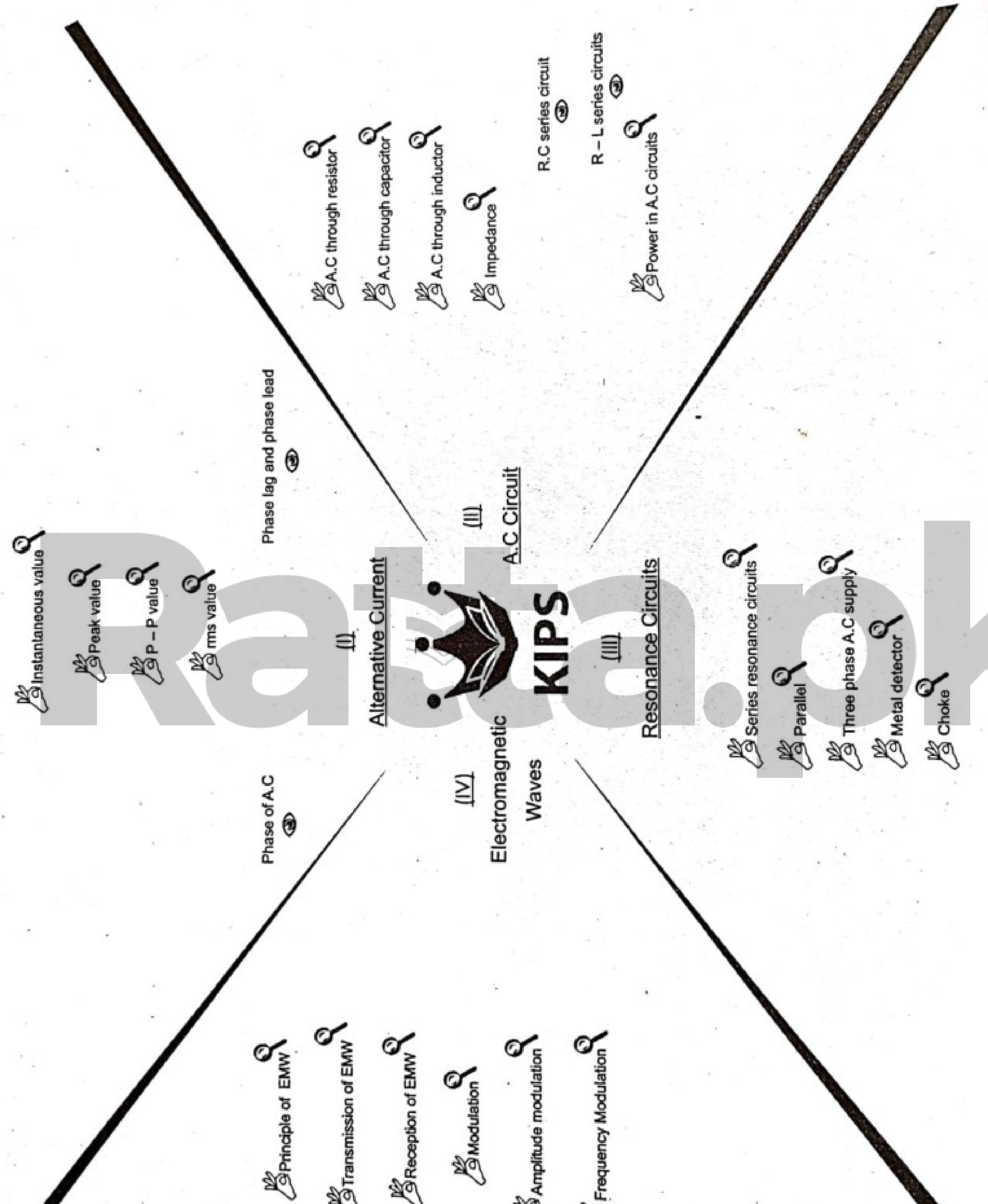
(36) **Self inductance of a long solenoid is**
(a) $\mu_o n^2 \ell A$
(b) $\mu_o n^2 A/\ell$
(c) $\mu_o N^2 \ell A$
(d) $BA\ell N$

(37) **An electric current induced within the body of a conductor when that conductor either moves through a non uniform magnetic field or in a region where there is a change in magnetic flux is called**
(a) Induced current
(b) Eddy current
(c) Back emf
(d) None of the above

(38) **The direction of induced current is such that it opposes the every cause that has produced it. This is law of**
(a) Faraday
(b) Lenz
(c) Ampere
(d) Fleming

(39) **Transformer works on the principle of**
(a) Lenz's law
(b) Faraday's law
(c) Mutual induction
(d) Law of conservation of power

(40) **When the motor is at its maximum speed, then back emf will be**
(a) Maximum
(b) Zero
(c) Intermediate values
(d) None of these


KIPS
(I) Alternative Current
Instantaneous value
Peak value
P – P value
rms value
Phase lag and phase lead
Phase of A.C
(II) A.C Circuit
A.C through resistor
A.C through capacitor
A.C through inductor
Impedance
R.C series circuit
R – L series circuits
Power in A.C circuits
(III) Resonance Circuits
Series resonance circuits
Parallel
Three phase A.C supply
Metal detector
Choke
(IV) Electromagnetic Waves
Principle of EMW
Transmission of EMW
Reception of EMW
Modulation
Amplitude modulation
Frequency Modulation

INTRODUCTION

- A.C is the current produced by a voltage source that reverses its polarity with time.
- *Time period T of alternating current or voltage* (that produced it) is the time interval T in which the source voltage **reverses its polarity once.**
- The *sinusoidal waveform of A.C* is a graph between **voltage and time.**
- **The voltage of A.C generator varies with time and at an instant.**

$$V = V_o \sin \omega t$$

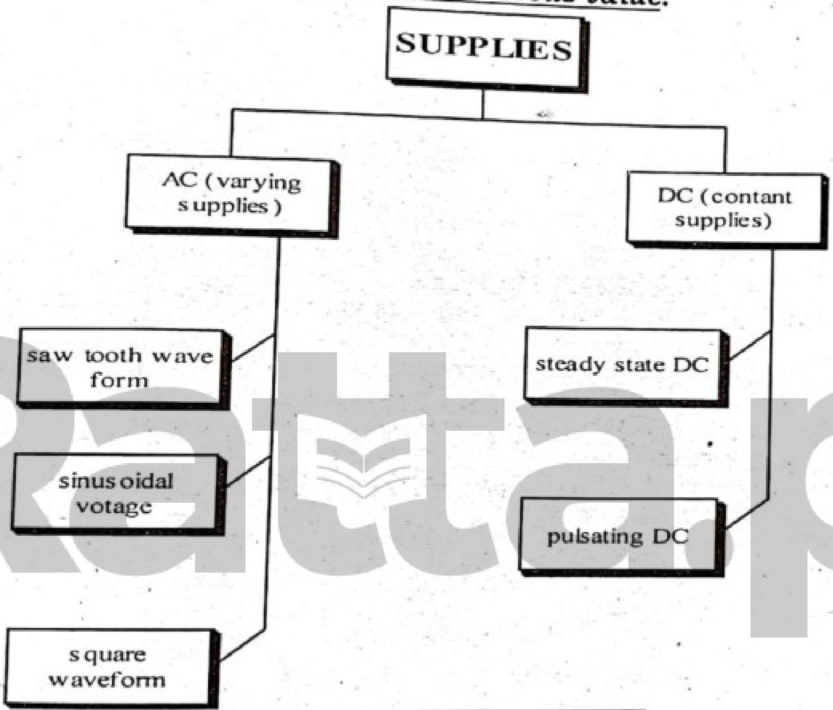
$$= V_o \sin \frac{2\pi}{T} t$$

$$= V_o \sin 2\pi f t$$

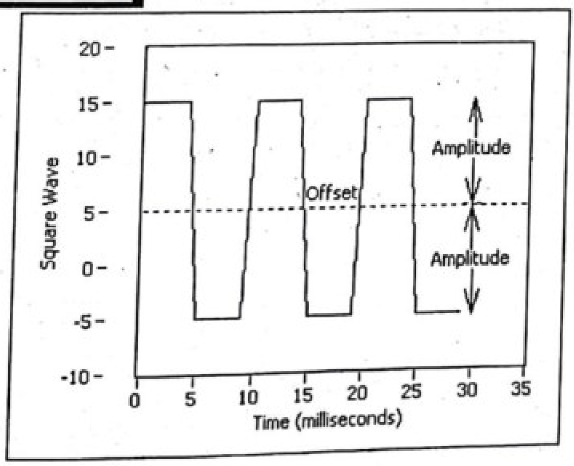
$$\mathbf{V = V_o \sin\theta}$$

Where $\theta = \omega t$ is the angle through which coil rotates in time 't'.

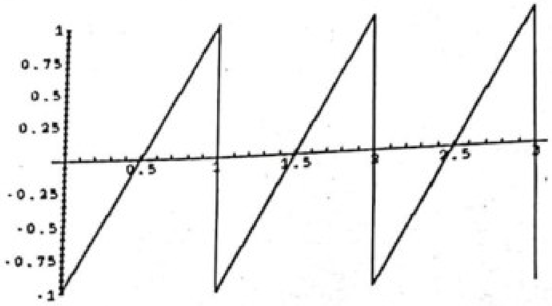
θ is the phase which specifies instantaneous value.

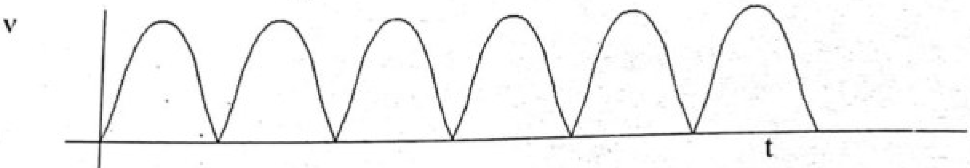


SQUARE WAVE



SAWTOOTH WAVE





Pulsating D.C

Instantaneous Values

The value of voltage or current that exists at any given instant 't' in a circuit is known as instantaneous value.

$$V_{inst} = V = V_o \sin\theta = V_o \sin 2\pi ft = V_o \sin\omega t$$

or $$I_{inst} = I = I_o \sin\theta = I_o \sin 2\pi ft = I_o \sin\omega t$$

V is the instantaneous value between $+V_o$ & $-V_o$

- *Sinusoidal graph* is the set of all instantaneous values.

Peak value (V_o or I_o)

*It is the highest value for **voltage or current***

Peak to Peak Value

It is the sum of +ve & -ve peak values

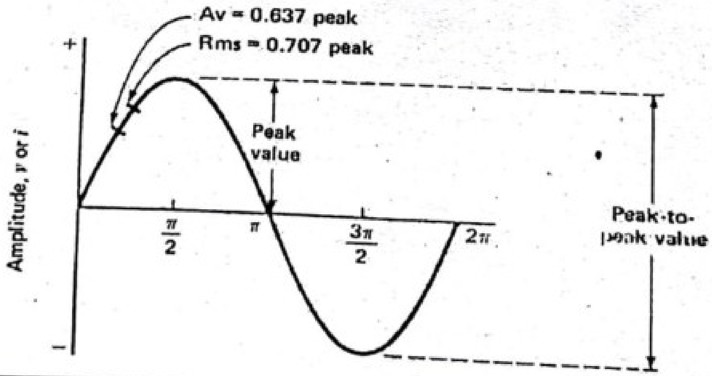
Root mean square (rms) value:-

It is the square root of the average of squared instantaneous values of voltage or current in a period.

$$V_{rms} = V_o/\sqrt{2} = 0.707V_o$$

$$I_{rms} = \frac{I_o}{\sqrt{2}} = 0.707I_o$$

rms value is also called effective value.



Do you know?

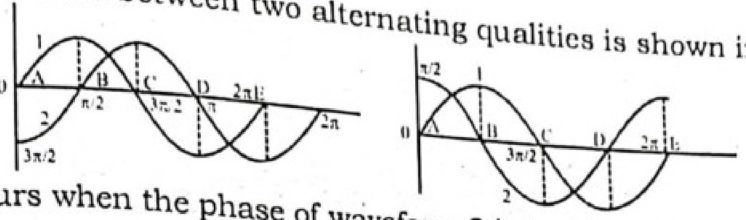
The average value of a sinusoidal symmetrical signal is zero over a cycle but RMS value is not. That is why practically all the calculations are based on RMS value.

Phase

The angle θ which specifies the instantaneous value of alternating voltage or current is known as its phase.

Phase Lag and Phase lead

The phase difference between two alternating qualities is shown in figure.



- Phase lag occurs when the phase of waveform 2 is less than the phase of waveform 1.
- Phase lead occurs when the phase of waveform 2 is greater than the phase of waveform 1.

Representing Phases And Alternating Quantities By Vectors

Projection of a counter **clockwise rotating vector** along represents a **sinusoidally alternating** voltage or current.

VECTOR DIAGRAM

A set of counter clockwise rotating vectors whose lengths represents the peak values or rms value of the signals and the angle between them represents the change of phase in AC signals is collectively called as vector diagram.

D.C CIRCUIT

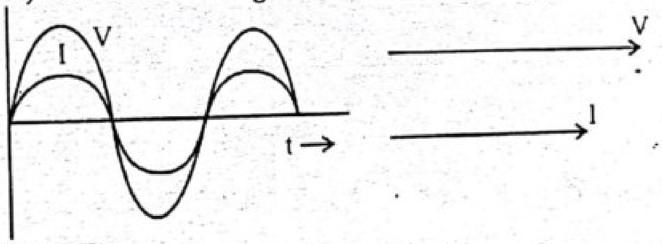
- Resistor R is the basic circuit element in D.C circuit.
- R controls voltage and current
- Ohm's law can be used.

A.C CIRCUIT

- Resistor ( ), inductor ( ) & capacitor ( ) These are three main components of a AC circuit:-

A.C THROUGH RESISTOR

- Through resistor, $V = V_o \sin\omega t$ and $I = I_o \sin\omega t$ **voltage and current are in** phase.
- If one increases or decreases, the other **does the same.**
- *$P = VI = I^2R = V^2/R$, holds true only when V & I are in phase.*



A.C THROUGH CAPACITOR

- **Due to D.C, a capacitor behaves as insulator. It only stores charge.**
- *Due to A.C, a capacitor behaves as conductor.*
- Through capacitor, charge on parallel plates of a capacitor, $q = CV_o \sin\omega t = q_o \sin(\omega t)$
- Current leads voltage by phase $\theta = 90^\circ$ or $\pi/2$
- A.C can pass through capacitor (seems passing) because of the continuously reversing polarity.
- Reactance = measure of opposition of capacitance against flow of A.C.
- Reactance is measured in ohms

$$X_c = \frac{V_{rms}}{I_{rms}} = \frac{1}{2\pi fC} = \frac{1}{\omega C}$$

- As frequency increases X_c decreases.
- Voltage lags current by 90° in a pure capacitive circuit

A.C THROUGH INDUCTOR

- Through inductor, A.C produces self-inductive effects because it constantly changes.
- When potential difference is applied back emf is produced.

$$\epsilon_L = \frac{L\Delta I}{\Delta t},\ V = \frac{L\Delta I}{\Delta t}$$

- Current lags behind voltage by 90° or $\pi/2$.
- Inductive reactance is measure of opposition offered by the inductor coil to the flow of A.C through it.

$$X_L = \frac{V_{rms}}{I_{rms}} = 2\pi fC = \omega C$$

$X_L = V/I = 2\pi fL = \omega L$

- *As frequency increases X_L increases*
- *In a pure inductor, energy gained = energy given out*
- No power loss in pure inductive or capacitive circuit takes place.

Current lags voltage by 90° in inductive circuit.

IMPEDANCE (Z)

Combined effect of resistance R, capacitive reactance X_c & inductive reactance X_L in a circuit in which A.C is provided is called impedance.

$$Z = \frac{V_{rms}}{I_{rms}}$$

Impedance is measured in ohms.

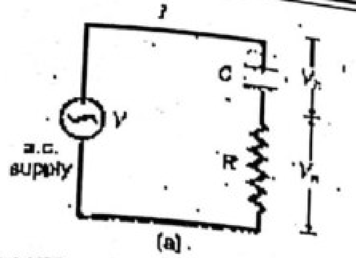
Circuit Element(s)	Impedance (Ω)	Phase Angle (ϕ)
R	$Z = R$	0°
L	$Z = X_L = \omega L$	+90°
C	$Z = X_C = 1/\omega C$	-90°
R L	$Z = \sqrt{R^2 + X_L^2}$	$0° < \phi < 90°$
R C	$Z = \sqrt{R^2 + X_C^2}$	$-90° < \phi < 0°$
R L C	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	$\phi > 0°$ if $X_L > X_C$ $\phi = 0°$ if $X_L = X_C$ (Resonance) $\phi < 0°$ if $X_L < X_C$

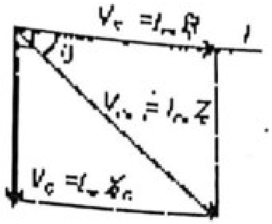
Note: *Current vector is taken along X-axis*

R-C SERIES CIRCUIT

$$\text{Impedance } Z = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

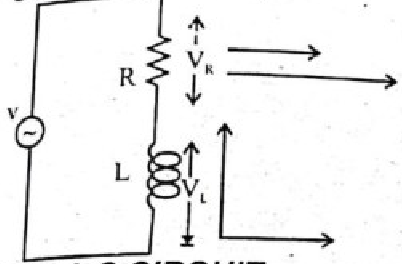
- Phase between V & I is $\theta = \tan^{-1}(1/\omega CR)$
- *Current leads voltage.*

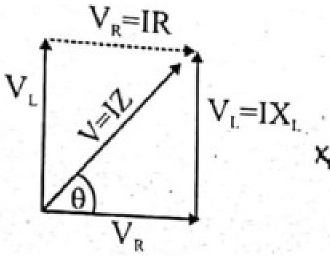


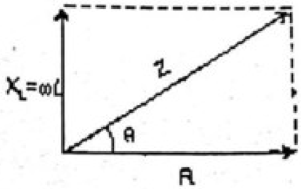


R-L SERIES CIRCUIT

- Impedance $Z=\sqrt{R^2+(\omega L)^2}$
- **Phase between V & I is $\theta = \tan^{-1}(\omega L/R)$**
- *Current lags voltage*





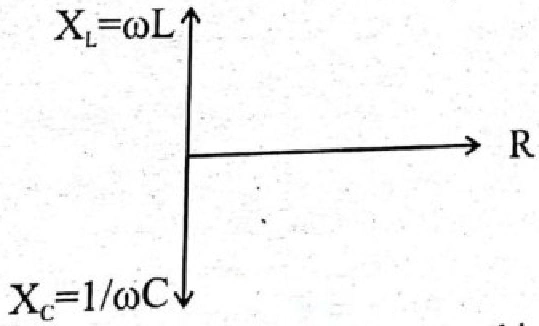


POWER IN A.C CIRCUIT

- *Power dissipation = 0,* in purely **inductive & capacitive circuit**
- **p = VI only when V & I are in phase in a purely resistive circuit.**
- *P = IV cosθ* in real L & C circuit where cosθ is power factor & Vcosθ is component voltage vector **along current.**

SERIES RESONANCE CIRCUIT

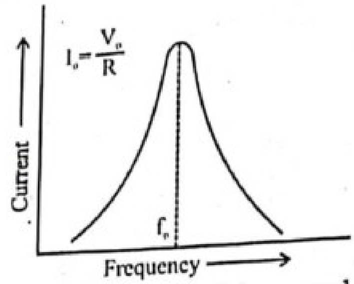
- $X_L = \omega L$ and $X_C = \dfrac{1}{\omega C}$
- *At low frequency capacitance* ***dominates*** *and circuit behave as R-C series circuit and at high frequency inductance* ***dominates and circuit behave as R-L series circuit.***
- The impedance diagram is shown in figure



- If $X_L = X_C$, then it is 'resonance' and frequency at this time is called ***resonance frequency.***

$\omega_r L = 1/\omega_r C$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$



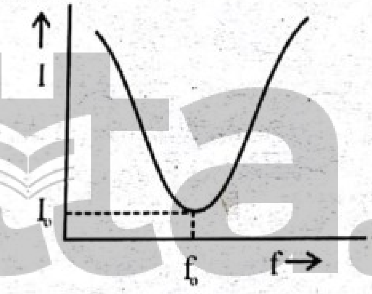
- At resonance, impedance is minimum and is equal to R.
- At resonance V_L, the voltage drop across inductance and V_C the voltage drop across capacitance may be much larger than the source voltage.

PARALLEL RESONANCE CIRCUIT

- The resonance frequency is

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

- At resonance the impedance is maximum. Hence current is minimum at resonance and **in phase** with voltage.
- At resonance branch currents may be larger than source currents.
- At resonance power factor is one



THREE PHASE A.C SUPPLY

- In three phase A.C generator, there are three coils inclined at **120° angle** to each other.
- Each coil is connected to its own **pair of slip** rings.
- In three-phase supply, total load is divided in three parts.
- *There will be no drop of voltage supply in three phases.*
- *Three-phase supply can provide 400V between two lines.*
- *The line to neutral voltage is 230V.*
- *Star type connection is used to connect three phase wires and one neutral wire.*

PRINCIPLE OF METAL DETECTOR

- Coil (L) & Capacitor (C) are coupled to produce **oscillations of currents**.
- *L-C circuit behaves like an oscillating* ***mass spring system.***
- Energy oscillates between a capacitor and inductor called *an electrical oscillator.*
- *L-C circuit* produce **beats phenomenon** for metal detection.

CHOKE

- It is *an inductive coil.*
- (It consumes extremely **small power.**)
- It is used in A.C circuit to limit current.

ELECTROMAGNETIC WAVES (EMW)

- Electromagnetic waves were *predicted by Maxwell and experimentally produced by* ***Frank Hertz.***
- Electromagnetic waves are ***oscillating electric and magnetic fields***

- Changing magnetic flux produces electric field given by; $E = \left(\frac{1}{2\pi r}\right)\frac{\Delta\phi_m}{\Delta t}$
- Changing electric flux produces magnetic field given by; $B = \left[\frac{\mu_o \in_o}{2\pi r}\right]\frac{\Delta\phi_e}{\Delta t}$
- Speed of e.m waves in vacuum is given by $v = \frac{1}{\sqrt{\mu_o \in_o}} = 3\text{x}10^8 \text{msec}^{-1}$
- The frequency is about **10^6Hz depending upon wavelengths.**

PRODUCTION OF E.M WAVES

- E.M waves in laboratory are produced by **oscillation of electrons.**
- Frequency of oscillatory circuit is $f = \frac{1}{2\pi\sqrt{LC}}$

RECEPTION OF E.M WAVES

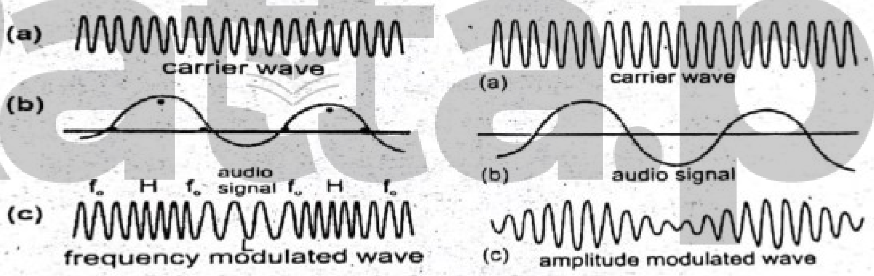
The reception of EMW is based on a LC circuit in which the value of inductance is fixed but varying capacitance gives different frequencies.

MODULATION

The process of mixing the low frequency signal (sound) with high frequency radio waves is called **modulation.**

*The resultant wave is called **modulated wave.***

Types



- ✦ Amplitude modulation (A.M)
- ✦ Frequency modulation (F.M)
- ✦ Phase modulation. (P.M)
- Modulated waves are demodulated by receiving sets (TV or radio set), rectified and then detected.
- Detection of modulated wave takes place only when frequency of tuning circuit equals to that of transmitting circuit and **hence *electrical resonance* is produced**.

Do you know?

- Frequency range of A.M signal 540KHz to 1600KHz
- Frequency Range of F.M signal 88MHz to 108MHz
- F.M signal does not contain any noise signal as the A.M does.

PRACTICE EXERCISE

30 mins Time Yourself

(1) **A choke is used as a resistance in ________**

(a) DC circuit
(b) AC circuits
(c) Both AC and DC circuit
(d) Full wave rectifier circuit

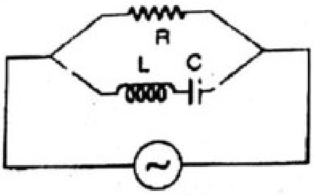
(2) **At resonance the value of the power factor in an L-C-R series circuit is ________**

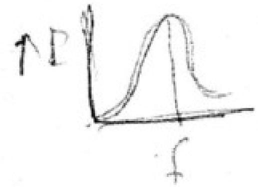
(a) Zero
(b) $\frac{1}{2}$
(c) 1
(d) not definite

(3) **An A.C series circuit contain 4Ω resistance and 3-Ω inductive reactance. The impedance of the circuit is ________**

(a) 1 Ω
(b) 5 Ω
(c) 7 Ω
(d) $7/\sqrt{2}$ Ω

(4) **The current in resistance R at resonance is**

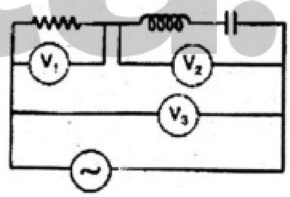




Imp

(a) zero
(b) minimum but finite
(c) maximum but finite
(d) infinite

(5) **A resistor R, an inductor L, a capacitor C and voltmeters V_1, V_2 and V_3 are connected to an oscillator in the circuit as shown in the following diagram. When the frequency of the oscillator is increased, then at resonance frequency, the voltmeter reading is zero in the case of:**



(a) voltmeter V_1
(b) all the three voltmeters
(c) voltmeter V_3
(d) voltmeter V_2

(6) **The phase angle between the voltage and the current in an AC circuit consisting of a resistance is ________**

(a) Zero
(b) 45°
(c) 90°
(d) 180°

(7) **In an LCR series circuit, if V is the effective value of the applied voltage, V_R is the voltage across R, V_L is the effective voltage across L & V_c is the effective voltage across C then ________**

(a) $V = V_R+V_L+V_C$
(b) $V^2=V_R^2+V_L^2+V_C^2$
(c) $V^2=V_R^2+(V_L-V_C)^2$
(d) $V^2=V_L^2+(V_R-V_C)^2$

(8) **When a voltage $V = V_o \cos \omega t$ is applied across a resistor of resistance R, the average power dissipated per cycle in the resistor is given by________**

(a) $\frac{V_o}{\sqrt{2}R}$
(b) $\frac{V_o}{\sqrt{2\omega R}}$
(c) $\frac{V_o^2}{2R}$
(d) $\frac{V_o^2}{2\omega R}$

(9) **Radio receivers are usually tuned by adjusting the capacitor of an LC circuit. If $C = C_1$ for a frequency of 600kHz, then for a frequency of 1200kHz one must adjust C to**

(a) $C_1/2$
(b) $C_1/4$
(c) $2C_1$
(d) $4C_1$

$f_c = \frac{1}{2\pi\sqrt{LC_1}}$ $\frac{1}{2\pi\sqrt{L\frac{C_1}{4}}}$ $= \frac{1}{2\pi\sqrt{LC_1}}$ $= 2\left(\frac{1}{2\pi\sqrt{C_1L}}\right)$

(10) **An inductor may store energy in ________**

(a) its electric field
(b) its coils
(c) its magnetic field
(d) both electric and magnetic fields

(11) **Average value of current and voltage over a cycle of AC is**

(a) Positive
(b) negative
(c) both
(d) zero

(12) **A changing magnetic flux produces around itself an induced ________**

(a) Magnetic field
(b) Electric field
(c) Electromagnetic force
(d) Artificial gravitational field

(13) **Maxwell derived mathematically that the velocity of the electromagnetic waves is ________**

(a) $\frac{1}{\epsilon_o}$
(b) $\frac{1}{\sqrt{\frac{\mu_o}{\epsilon_o}}}$
(c) $\sqrt{\mu_o \epsilon_o}$
(d) $\frac{1}{\sqrt{\mu_o \epsilon_o}}$

(14) **Electromagnetic waves travel in free space with the speed of ________**

(a) γ-rays
(b) Positive rays
(c) Cathode rays
(d) β-rays

(15) **The direction of propagation of an electromagnetic waves is ________**

(a) Perpendicular to electric field
(b) Perpendicular to both electric and magnetic field
(c) Perpendicular to magnetic field
(d) Parallel to electric and magnetic field

(16) **An electromagnetic wave consists of ________**

(a) Electric and magnetic fields moving parallel to each other
(b) Magnetic field moving with velocity of light in space
(c) Electric field moving with velocity of light
(d) Electric and magnetic fields moving perpendicular to each other

(17) **Electromagnetic waves transport ________**

(a) Energy
(b) Mass
(c) Heat
(d) None

(18) **Waves emitted from the antenna are ________**

(a) Sound waves
(b) Electromagnetic waves
(c) Radio waves
(d) Modulated waves

(19) **A choke coil has**

(a) High inductance and high resistance
(b) High inductance and low resistance
(c) Low inductance and high resistance
(d) Low inductance and low resistance

Chapter-16

(20) Natural or resonant frequency of an LC circuit is ________

(a) $\frac{1}{4\pi\sqrt{LC}}$ (b) $2\pi\sqrt{LC}$

(c) $\frac{1}{\sqrt{LC}}$ (d) $\frac{1}{2\pi\sqrt{LC}}$

(21) If capacitance of L-C circuit is made four times then frequency of the circuit becomes ________

(a) Twice (b) One half

(c) Four times (d) None

(22) In a purely capacitive circuit the current:

(a) leads the voltage by one-fourth of a cycle (b) 15secleads the voltage by one-half of a cycle

(c) lags the voltage by one-fourth of a cycle (d) lags the voltage by one-half of a cycle

(23) The value of the steady current, which when flowing through the same resistor produces heat at the same rate as the mean rate of heat produced by the alternating current, is ________

(a) Average current (b) Sinusoidal current

(c) r.m.s current (d) Net current

(24) To find the r.m.s value of an alternating current mathematically, we need to have ________

(a) Mean value of I^2 (b) Square root of mean value of I^2

(c) Square root of I^2 (d) Square of I/2

(25) An alternating current of r.m.s value of 4.0 A and frequency 50Hz flows in a circuit containing 10Ω resistor. The peak current is then

(a) 20A (b) 20.66A

(c) 6.66A (d) 5.66A

(26) An alternating current of r.m.s value of 2A and a steady direct current I flowing through identical resistors dissipate heat at the same rate. What is the current I?

(a) 2A (b) $\sqrt{2}$A

(c)1A (d) $2\sqrt{2}$A

(27) An alternating current is represented by the equation $I = I_0\sin\omega t$, which of the following equation represents an alternating current of frequency and amplitude twice that of the above current?

(a) $I = 2I_0\text{Sin}(\omega t/2)$ (b) $I=2I_0\text{Sin}(2\omega t)$

(c) $I=2I\sin\omega t$ (d) $I=I_0\sin(2\omega t)$

(28) In pure resistor circuit, the voltage and current are

(a) Lagging each other (b) at 90° phase difference

(c) zero phase difference (d) No phase difference

(29) The power factor of an ac circuit has the value

(a) Unity when the circuit contains only an inductance

(b) Unity when the circuit contains only a resistance

(c) Unity when the circuit contains resistance and capacitor

(d) Unity when the circuit contains only a capacitance

(30) In capacitive circuit, the current ________

(a) Lags behind voltage by $\pi/2$ (b) Is in phase with voltage

(c) Opposite in phase of voltage by π (d) Leads the voltage by $\pi/2$

(31) A 100μF capacitor with 12V source in series having frequency 50Hz, will offer a capacitive reactance of about ________

Imp
(a) 32Ω
(b) 60 Ω
(c) 50 Ω
(d) 100 Ω

(32) If a glass plate is inserted in between the plate of a capacitor in series with a lighted bulb, the brightness of the bulb ________

(a) Remains same
(b) Brightness increases
(c) Brightness decreases
(d) No light

C↑ X_c↓
I↑

(33) The impedance of an RLC series circuit is definitely increased if:

(a) C decreases
(b) R increases
(c) L decreases
(d) L increases

$X_L = 2\pi f L$
$X_C = \frac{1}{2\pi f C}$

(34) A wire of resistance R is coiled inductively so that its inductance is L. The impedance of the coil at a frequency of f is ________

(a) $(R+2\pi fL)^{1/2}$
(b) $R+1/2\pi fL$
(c) $(R^2+f^2L^2)^{1/2}$
(d) $(R^2+4\pi^2f^2L^2)^{1/2}$

(35) Ammeter connected in an AC circuit measures ________

Imp
(a) Exact value of current
(b) rms value of current
(c) Net value of current
(d) Peak value of current

(36) When a pure inductor of inductance L, and a pure capacitor of capacitance C are connected in parallel to a sinusoidal potential difference V, the potential difference across both L&C will be ________

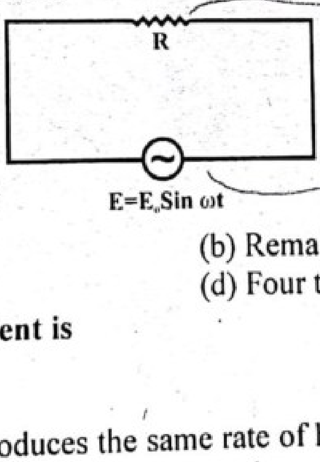
Imp
(a) Same
(b) Different
(c) At L will be more than at C
(d) At L will be less than at C

(37) When the frequency of the oscillator in a series RLC circuit is doubled

Imp
(a) the capacitive reactance is doubled
(b) the capacitive reactance is halved
(c) the impedance is doubled
(d) he current amplitude is halved

(38) In the following circuit diagram if the frequency of the source is double then the value of current flowing in R will become

Imp



$E=E_o\text{Sin }\omega t$

$I = V/R$ → No dependence
$I = I_0 \sin wt$

(a) Double
(b) Remain unchanged
(c) Half
(d) Four times

(39) The rms value of an ac current is

(a) its peak value
(b) s average value
(c) that steady current that produces the same rate of heating in a resistor as the actual current
(d) that steady current that will charge a battery at the same rate as the actual current

(40) A 10Ω electric heater is connected to a 220V, 50Hz mains supply. What is the peak value of the potential difference across the heater element?

(a) 220V
(b) $220/\sqrt{2}$V
(c) 110V
(d) $220\sqrt{2}$V

KIPS

(I) Classification of solids

- Crystalline solids
- Amorphous solid
- Polymeric solid
- Crystal Lattice
- Properties of solids

Deformation of solids

Elastic constant

Stress and strain

Strain energy in deformed materials

(II) Electrical Properties of Solids

- Energy Band Theory

Insulator

Conductors

Semi conductor

(III) Magnetic Properties of Solids

- Ferromagnetic materials
- Diamagnetic materials
- Paramagnetic materials

(IV) Hysteresis

- Hysterisis loop

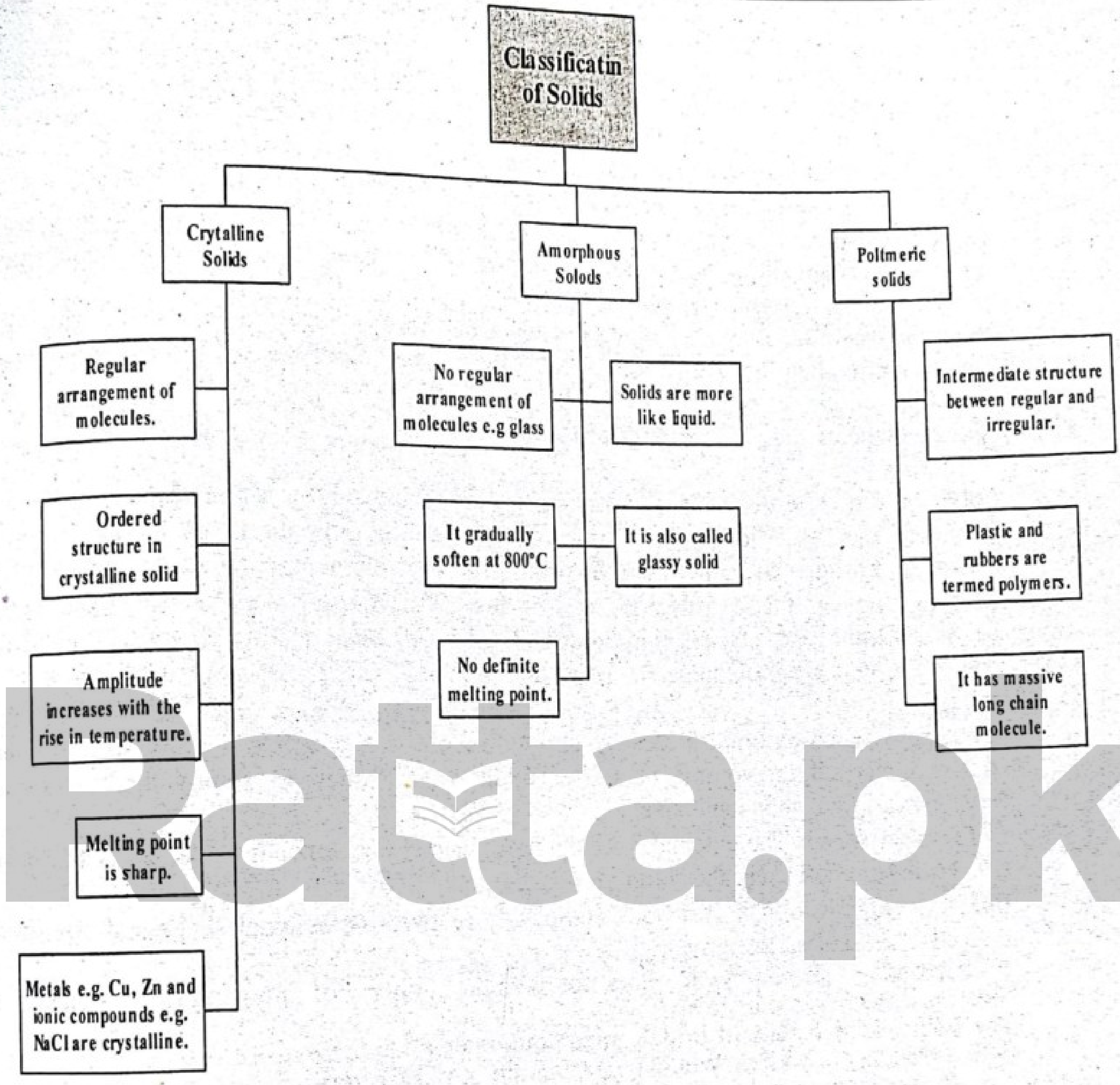
Saturation

Remanance

Coercitivity

Area of loop

- Hysterisis loss



SOLIDS

All solids are made up of atoms and molecules but due to their different internal arrangement of the molecules inside them, they are different classes:

(i) **Crystalline Solids:** The solids in which the atoms are arranged in a definite, regular and long range order are said to be crystalline.

Example: Quartz, mica, sugar, copper Sulphate, sodium chloride etc.

Properties:

- They have long range symmetry, i.e., regular arrangement is extended over a large volume of the crystal.
- They possess uniform chemical composition.
- The physical properties like thermal conductivity, electrical conductivity, compressibility, refractive index etc, have different values in different directions.
- They have flat surface.

(ii) **Amorphous Solids:** The solids in which the atoms are arranged in indefinite, irregular and short range order are said to be amorphous.

Example: Glass, rubber, sulphur etc.

Properties:

- The distribution of atoms or molecules in these solids is random.
- They are isotropic, i.e., they have same physical properties in all directions.
- Amorphous solids do not have sharp melting points.
- They have no characteristic geometrical shape.

(iii) **Crystal Lattice:** A crystal structure is a periodic arrangement of points in space and is obtained by associating with every lattice point a unit assembly or basis of atoms, identical in composition, arrangement and orientation.

(iv) **Polymeric Solids:** Polymers may be said to be more or less solid materials with a structure that is intermediate between order and disorder. They can be classified as partially or poorly crystalline solids.

Example: Polythene, polystyrene and nylon etc.

Properties:

- Polymers form a large group of naturally occurring and synthetic materials.
- Polymers consist wholly or in part of chemical combinations of carbon with oxygen, hydrogen, nitrogen and other metallic or non-metallic elements.
- Plastics and synthetic rubbers are termed 'Polymers' because they are formed by polymerization reactions in which relatively simple molecules are chemically combined into massive long chain molecules, or "three dimensional" structures.

ELASTICITY

- **Elasticity:** When external forces are applied on a body, which is not free to move, there is a change in its length, volume or shape. When these forces are removed, the body tends to regain its original shape and size.
- **Deforming force:** The external force acting on a body on account of which its size or shape or both changes is defined as the deforming force.
- **Perfectly elastic body:** If a body completely recovers its original shape and size, it is called perfectly elastic. Example is quartz.
- **Plastic body:** The body which does not have the property of opposing the external deforming force, is known as a plastic body.
  The bodies which remain in deformed state ever after removal of the deforming forces, are defined as plastic bodies. Wet clay is example of plastic body.

Note: Actually no body is perfectly elastic or perfectly plastic. All bodies behave in between two limits. We may consider quartz as almost perfectly elastic and putty or wet clay as almost perfectly plastic.

STRESS

- The internal restoring force acting per unit area of a deformed body is called stress.
- Since in equilibrium, the magnitude of the external force is equal to the restoring force, the stress in equilibrium is measured by the external force per unit area.
- If a force F is applied on area A, in equilibrium Stress = F/A.
- The stress developed in a body depends upon the way in which external force is applied on the body.
- Unit of stress is Nm^{-2} and its dimension is $\left[ML^{-1}T^{-2}\right]$
- Depending upon, how the external forces are applied on a body, the stress is of three types.
  (a) Longitudinal stress **(b)** Volume stress **(c)** Tangential or shearing stress

(a) **Longitudinal stress:**

- When the stress is normal to the surface of the body, then it is known as longitudinal stress.
- This type of stress is produced due to deformation in length or volume of the body.
- Longitudinal stress is of two types: **(i)** Tensile stress **(ii)** Compression stress

- The longitudinal stress produced due to increase in length or volume of a body is defined as tensile strength.
- The longitudinal stress, produced due to decrease in length or volume of a body, is defined as compression stress.

(b) **Volume stress**

- If equal normal forces are applied on every surface of a body, then it undergoes change in volume. The force opposing this change in volume per unit area of cross-section is defined as volume stress.
- It is numerically equal to the applied external force per unit area of cross-section and acts outwards.

(c) **Shear stress**

- When the stress is tangential or parallel to the surface of a body, then it is known as shear stress.
- Due to this stress, the shape of the body changes or it get twisted.

STRAIN

When deforming forces are applied on a body it undergoes a change in shape or size. The fractional (or relative) change in shape or size is called the strain. That is,

$$\text{Strain} = \frac{\text{Change in dimension}}{\text{Original dimension}}$$

- The form of strain depends upon the directions of applied force.
- Strain is ratio, hence it has no unit and no dimension.
- Depending upon the way, the deforming forces are applied on a body, strain is of three types.

(a) **Longitudinal (linear) strain**

- It is the ratio of change in length (Δl) to the original length (l).

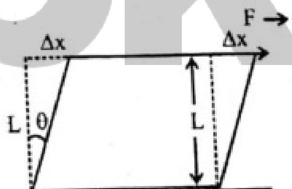
$$\text{Strain} = \frac{\text{Change in length}}{\text{Its original length}}$$

(b) **Volume strain**

- It is the ratio of the change in volume (ΔV) to the original volume (V). $\text{Volume strain} = \frac{\Delta V}{V}$

(c) **Shearing strain**

- The angular deformation (θ) in radians is called shearing strain. Since θ is small, we may write. Shearing strain $= \theta = \tan\theta = \frac{\Delta x}{L}$



TYPES OF MODULUS OF ELASTICITY

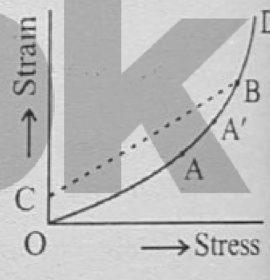
YOUNG'S MODULUS	BULK MODULUS	SHEAR MODULUS
• The ratio of the longitudinal stress to the linear strain is called Young's modulus Y, of the material	• The ratio of normal stress (pressure) to the volume strain is called bulk modulus K.	• The ratio of the shearing stress to the shearing strain is called the modulus of rigidity η, of the material.
• $Y = \frac{\text{Linear stress}}{\text{Longitudinal strain}}$ $Y = \frac{FL}{A\Delta L} = \frac{mgL}{\pi r^2 \Delta L}$	• $K = \frac{\text{Volume stress}}{\text{Volume strain}}$ $K = \frac{FV}{A(\Delta V)}$	• $G = \frac{\text{Shear stress}}{\text{Shear strain}} = \frac{F/A}{\theta}$ $G = \frac{F}{A\theta}$
• Young's modulus of elasticity is numerically equal to that force which when applied on the	• For gases, bulk modulus is of two types (a) Isothermal bulk	• The concept of shear applies only to solids. The reason is that shear forces are required to deform a

wire of the unit cross-section, doubles its length.	(b) modulus of elasticity. Adiabatic bulk modulus of elasticity.	solid and the solid tends to return to its original shape when the shear forces are removed.
• Y is the characteristic property of solid materials only.	• The value of K is maximum for solids and minimum for gases.	• Shear modulus does not apply on gases and liquid because gases and liquid do not have a definite shape to return to after deformation.

HOOKE'S LAW

- Within the elastic limits, the stress setup within an elastic body is proportional to the strain to which the body is subjected by the applied external force i.e., Stress x Strain or $\frac{\text{Stress}}{\text{Strain}}$ = a constant. The constant is called modulus of elasticity.
- The value of E depends upon the material of the body and not on the values of stress and strain.
- The values of E, for the same material, are different for different types of strains.
- The value of E depends upon the type of stress and strain produced rather than their values.
- Unit of modulus of elasticity is newton meter^{-2} (Nm^{-2}) or pascal.
- Its dimensional formula is $[ML^{-1}T^{-2}]$

ELASTIC LIMIT AND YIELD STRENGTH



- When stress is increased continuously, a point A is reache at which the strain increases more. This point is called **elastic limit.**
- Beyond elastic limit, the material does not return to its original condition when the deforming force is removed. It acquires what is called a **"permanent set".**
- On stressing a point B, is reached at which the material continues to strain without increase in load, i.e., the wire begins to **"flow down"** inspite of the same constant load. This point is called the **"yield point".**
- After a large strain. It reaches the **"breaking point"** D occurs in the material is called **"breaking stress"** or **fracture stress**.

STRAIN ENERGY IN DEFORMED BODIES

- In any type of strain, the work done per unit volume, i.e., potential energy or the strain energy per unit volume

$$U=\frac{1}{2}\times \text{Stress}\times \text{Strain} \text{ or } U=\frac{1}{2}\times \text{Young's moudlus}\times(\text{Longitudinal strain})^2 \text{ or}$$

$$U=\frac{1}{2}\times \text{Bulk modulus}\times(\text{Volume strain})^2 \text{ or } U=\frac{1}{2}\times \text{ Shear Modulus}\times(\text{Shearing strain})^2$$

ENERGY BANDS THEORY

A solid can be treated as a densely packed system obtained by bringing together isolated single atoms. An isolated single atom possesses a number of discrete energy levels that can be occupied by electros the atom. Generally the electrons exist in the **ground state,** when excited electrons can shift to higher energy levels. Usually only the valence electrons can participate in these excitations.

- An energy state, which cannot be occupied, is **forbidden gap.**

- The band formed by a series of energy levels containing the valence electrons is known as **valence band.** The valence band may be partially or completely filled up depending upon the nature of the crystal.
- The next higher permitted band is called as the **conduction band.** This band may be empty or partially filled. In conduction band the electrons can move freely.
- Metals have positive temperature coefficient (α_t) of resistance while semiconductors have negative (α_t).

Classification of solids: All solids employed in electrical work may be classified into the following three groups: **(a)** Conductors **(b)** Insulators **(c)** Semiconductors

CONDUCTORS	INSULATORS	SEMICONDUCTORS
• In the case of a conductor, there will be no forbidden energy gap. The conduction and valence energy bands overlap each other. Obviously, the electrons from the valence band can freely enter the conduction energy band. • In conductors, charge carries responsible for the conduction of electricity are **free electrons.** • The electrical conductivity of conductors is of the order of $10^8(\text{ohm}\times\text{metre})^{-1}$. • Metallic conductors have positive temperature coefficient of resistance. • The resistance of conductor increases due to addition of impurities.	• In the case of an insulator, the forbidden energy band is very wide and hence an electron cannot jump across, from the valence energy band to the conduction energy band. Only when a very large amount of energy is supplied, an electron may be able to jumps across the forbidden band. This explains why certain materials which are perfect insulators behave as conductors only at very high temperatures. In the case of diamond, the forbidden energy gap is nearly 6 eV. • In insulators, no free electrons are available for conduction. • In Insulators, the valence band is completely filled while conduction band is completely empty. • The electrical conductivity of insulators is very low in the range 10^{-16} to 10^{-6} $(\text{ohm-m})^{-1}$ • Ionic crystals are insulators. The other examples are glass, wood, paper, mica, diamond, ceramic, plastic etc.	• In the case of semiconductors, the forbidden energy band is comparatively small. For example 0.7eV for (Ge) and 1.1 eV for silicon. In these cases, when a small amount of energy is supplied, the electrons can easily jump across the forbidden energy band and reach the conduction energy band. • Semiconductor has a much smaller energy gap (E_g) between the top of the highest filled band (called **valence band)** and the bottom of the vacant band just above it called the **conduction band.** • The conductivity of semiconductors is of the order of $1(\text{ohm-m})^{-1}$. • The conductivity of semiconductors increase with increase in temperature. • In semiconductors, electrical conduction is due to electrons and holes. • Semiconductors have negative temperature coefficient of resistance. • The resistance of semiconductor decreases due to the addition of impurities. At absolute zero temperature, conduction band is completely empty and the semiconductor behaves as an insulator.

Types of Semiconductors

- N-type semiconductor
- P-type semiconductor

N-TYPE SEMICONDUCTOR

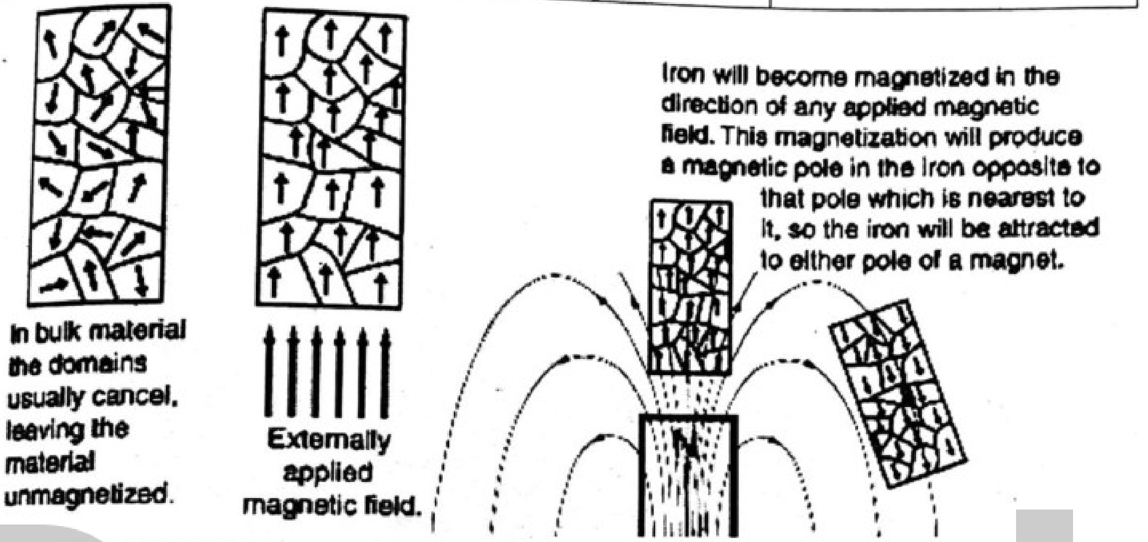
- When a small amount of **Pentavalent Impurity** (Examples: Phosphorus, arsenic, antimony etc.) is added to an intrinsic semiconductor, we obtain an N-type extrinsic semiconductor.
- In the N-type semiconductor, the number of electrons in the conduction band > number of holes in the valence band.
- The impurity atoms in N-type extrinsic semiconductor are called **donor atoms** as they donate an **extra** electron to pure semiconductor or host lattice.
- In the N-type semiconductor, electrons are called as **majority charge carriers,** whereas holes are called **minority charge carriers.**
- In the N-type semiconductor , the Fermi level shifts towards the conduction band.
- There is no charge on N-type semiconductor because it is formed by the combination of free negatively charged electrons and fixed majority carrier.

P-TYPE SEMICONDUCTOR

- When a small amount or **trivalent Impurity** (Examples: gallium, indium, boron, etc.) is added to an intrinsic semiconductor, we obtain a P-type extrinsic semiconductor.
- The impurity atoms in P-type extrinsic semiconductor are called acceptor atoms, as they accept an electron from the host lattice.
- In the P-type semiconductor, the number of holes in the valence band > number of electrons in the conduction band.
- In the P-type semiconductor **holes are majority charge carriers** while **electrons are minority charge carriers.**
- In P-type semiconductor, the Fermi level shifts towards the valence band.
- There is no charge on P-type semiconductor also, because it is formed by the combination of free positively charged holes and fixed negatively charged acceptor ions.
- The energy levels of the hole can also be calculated approximately using Bohr model.

DIAMAGNETISM	PARAMAGNETISM	FERROMAGNETISM
• Diamagnetic substances are feebly repelled by the magnet.	• Paramagnetic substances are feebly attracted by the magnet.	• Ferromagnetic substances are strongly attracted by the magnet.
• Atoms do not have any permanent dipole moment.	• Atoms have permanent dipole moments which are randomly oriented.	• Atoms have permanent dipole moments which are organized in domains.
• Magnetization is small, negative and varies linearly with field.	• Magnetization is small, positive and varies linearly with field.	• Magnetization is very large, positive and varies non-linearly with field.
• Susceptibility is small, negative and temperature independent.	• Susceptibility is small, positive and varies inversely with temperature.	• Susceptibility is very large, positive and temperature dependent.
• Relative permeability μ_r is slightly lesser than unity.	• Relative permeability is slightly greater than unity.	• Relative permeability is much grater than unity.
• This property is exhibited by solids, liquids and gases.	• This property is exhibited by solids, liquids and gases.	• The property is exhibited by solids only, that too crystalline.

• It is practically independent of temperature.	• It decreases with rise in temperature.	• It decreases with rise in temperature and above curie temperature becomes para.
• Bl, Cu, Ag, Hg, Pb, water hydrogen, He, Ne etc are diamagnetic.	• Na, K, Mg, Mn, Al, Cr, Sn and liquid oxygen are paramagnetic.	• Fe, Cc, Ni and their alloys are ferromagnetic.



SUPER CONDUCTORS

- Temperature at which material losses its resistivity and becomes super conductor is called **critical temperature.**
- The first super conductor was discovered in 1911.
- Critical temperature of Al (T_c=1.18K), tin (T_c=3.72K), lead (T_c=7.2K) & Hg(T_c=4.2K).
- Complex crystalline structure known as yttrium barium copper oxide ($YBa_2Cu_3O_7$) is super conductor at 163K i.e. at –110°C
- Any superconductor with a critical temperature above 77 k, the boilig point of liquid nitrogen, is referred as a high temperature superconductor.

Uses

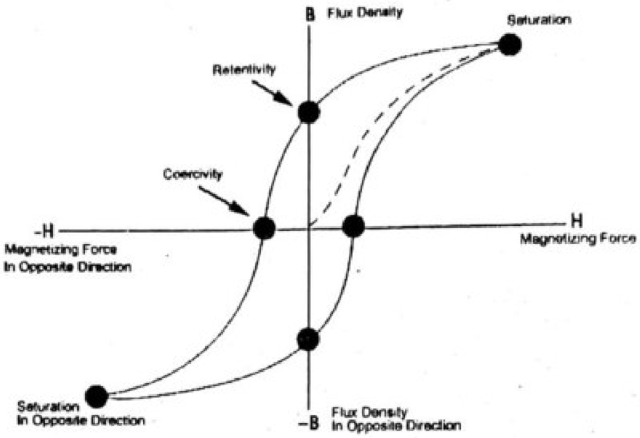
- Magnetic resonance **imaging (MRI)**
- Magnetic **Levitation trains**
- Powerful but **small electric motors**
- Faster computer chips
- Concentrating U^{235} gas in centrifuge system.

Magnetic Hysteresis

The value of flux density for any value of current is always greater when the current is decreasing, than when it is **increasing i.e. magnetism** lags behind **the magnetizing current.**

Saturation

The magnetic flux density increases from zero and reaches a maximum value. At this stage, the material is said to be **magnetically saturated.**



Remanence or Retantivity

When the current is reduced to zero, the material still remains strongly magnetized. It is due to the tendency of domains to stay partly in line, once they have **been aligned.**

Coercivity

To demagnetize the material, the magnetizing current is reversed and increased to reduce the **magnetization to zero;** this is known as coercive current.

- Once the material is magnetized, its magnetization curve never passes through the **origin.**
- The Coercivity of steel is more than iron, so it requires more current to demagnetize.

Area of loop

- The area of Hysteresis loop is a measure of the energy needed to magnetize and demagnetize the specimen during each cycle. This is the energy required to do work against internal friction of domains. This work is done against friction, is dissipated as heat. It is called ***Hysteresis loss.***
- A material with high retentively and large coercive force, would be most suitable to make a permanent magnet.

PRACTICE EXERCISE

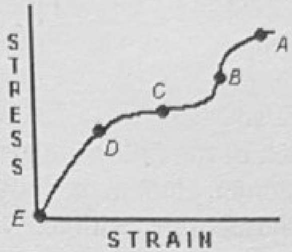
30 mins Time Yourself

(1) **Which of the following substances possesses the highest elasticity?**
(a) Rubber
(b) Glass
(c) Copper
(d) Steel

(2) **What is the SI unit of modulus of elasticity of a substance?**
(a) Nm^{-2}
(b) Jm^{-2}
(c) Nm^{-1}
(d) Being a number, it has no unit.

(3) **What are the dimensions of stress?**
(a) MLT^{-2}
(b) $ML^{-2}T^{-1}$
(c) $ML^{-1}T^{-2}$
(d) $ML^{O}T^{-1}$

(4) **The figure shows the stress-strain graph of a certain substance. Over which region of the graph is Hook's law obeyed?**



(a) AB
(b(BC
(c) CD
(d) ED

(5) **Which one of the following physical quantities does not have the dimensions of force per unit area?**
(a) Stress
(b) Strain
(c) Young's modulus
(d) Pressure

(6) **If a wire is stretched to double of its length then the strain will be**
(a) zero
(b) 1
(c) ½
(d) Double

(7) **A wire of length L is stretched by a length ℓ when a force F is applied at one end. If the elastic limit is not exceeded, the amount of energy stored in the wire is**
(a) Fℓ
(b) ½ (Fℓ)
(c) $F\ell^2/L$
(d) $\frac{1}{2}Fl^2$

(8) **When a force is applied at one end of an elastic wire, it produces a strain ϵ in the wire. If Y is the young's modulus of the material of the wire, the amount of energy stored per unit volume of the wire is given by**
(a) $Y\epsilon$
(b) $\frac{1}{2} Y\epsilon$
(c) $Y\epsilon^2$
(d) $\frac{1}{2} Y\epsilon^2$

(9) **A wire, suspended vertically from one end, is stretched by attaching a weight of 20 N to the lower end. The weight stretches the wire by 1mm. How much energy is gained by the wire?**
(a) 0.01J
(b) 0.02J
(c) 0.04J
(d) 1.0J

(10) **The area method to find energy stored in deformed material is valid for**
(a) Elastic region
(b) Non-elastic region
(c) Both a & b
(d) Elastic for small force

(11) **N-type crystals have**
(a) Positive charge
(b) Negative charge
(c) neutral
(d) none of these

(12) **The resistivity of semiconductor is of the order of**
(a) 10^{-6} to 10^{-4} Ωm (b) 10^{4} to 10^{6} Ωm
(c) 10^{-10} to 10^{-20} Ωm (d) 10^{7} Ωm

(13) **Materials that undergo plastic deformation before breaking are called**
(a) Brittle (b) Ductile
(c) Amorphous (d) Polymers

(14) **How does the Young's modulus relates with the temperature**
(a) inversely (b) directly
(c) does not depend (d) none of these

(15) **At 0 K a piece of Si has**

Conduction band	**Valence band**
(a) Filled	Filled
(b) Empty	Filled
(c) Empty	Empty
(d) Filed	Empty

(16) **Which of the following group represent doner atoms**
(a) Indium, aluminum, phosphorous (b) Aluminum, indium, gallium
(c) Phosphorous, antimony, arsenic (d) None

(17) **Any alteration produced in shapes, length or volume when a body is subjected to some external force is called**
(a) Stiffness (b) Toughness
(c) Extension (d) Deformation

(18) **The energy band occupied by the valence electrons is called**
(a) Energy state (b) Valence band
(c) –ve energy state (d) conduction band

(19) **The curie temperature is that at which**
(a) Semi-conductor becomes conductors (b) Ferromagnetic becomes paramagnetic
(c) Paramagnetic becomes diamagnetic (d) Metals become super conductor

(20) **A ferromagnet will become fully magnetized at**
(a) High voltage A.C (b) Low voltage A.C
(c) Alternating current at its peak value (d) D.C current at peak value

(21) **Which of the following produce magnetic field**
(a) Orbital motion of electron (b) Spin motion of electron
(c) Spin motion of nucleus (d) All

(22) **Materials in which valence electrons are tightly bound to their atoms at low temperature are called ____________**
(a) Semi conductor (b) Super conductors
(c) Insulators (d) Conductor

(23) **The modulus of elasticity of liquids is**
(a) 1 (b) zero
(c) infinity (d) none of these

(24) **The young's modulus of wire of length L and radius r is Y. If the length is reduced to L/2 and radius to r/2, its Young's modulus will be**
(a) Y/2 (b) 2Y
(c) Y (d) 4Y

(25) **Which of the following is not true for a crystalline substance?**
(a) short range order (b) no definite melting point
(c) Sharp melting point (d) all

(26) **A hole in a p – type semiconductor is**
(a) an excess electron (b) a missing electron
(c) a missing atom (d) a donor level

(27) **The band theory of solids explains satisfactorily the nature of**

(a) Electrical insulators alone (b) Electrical conductors alone

(c) Electrical semi conductors alone (d) All of the above

(28) **A vacant or partially filled band is called**

(a) Conduction band (b) Valence band

(c) Forbidden band (d) Empty band

(29) **A completely filled band is called**

(a) Conduction band (b) Valence band

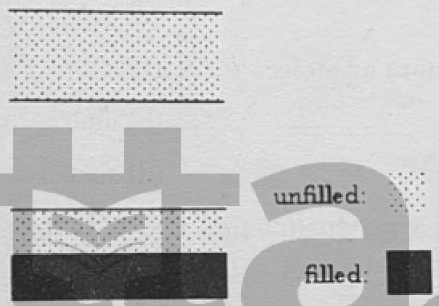
(c) Forbidden band (d) Core band

(30) **The electrons in conduction band are free to**

(a) Transport vibrations (b) Transport signals

(c) Transport charge (d) Transport impulses

(31) **The energy level diagram shown applies to:**



(a) Semi conductor (b) an isolated molecule

(c) an insulator (d) a conductor

(32) **With increase in temperature the electrical conductivity of intrinsic semi conductor**

(a) Decreases (b) Increases

(c) Remains same (d) First increases then decreases

(33) **Holes can exist in**

(a) Conductors (b) Insulators

(c) Semi conductors (d) All of the above

(34) **Young's modulus is a proportionality constant that relates the force per unit area applied perpendicularly at the surface of an object to:**

(a) the shear (b) the fractional change in volume

(c) the fractional change in length (d) the pressure

(35) In a semiconductors, the charge carriers are ____________

(a) Holes only (b) Electrons only

(c) Electron and holes both (d) All of the above

(36) The ultimate strength of a sample is the stress at which the sample:

(a) remains underwater

(b) returns to its original shape when the stress is removed

(c) bends 180°

(d) breaks

(37) Very weak magnetic fields are detected by __________

(a) Squids (b) Magnetic resonance imaging (MRI)

(c) Magnetometer (d) Oscilloscope

(38) Energy needed to magnetize and demagnetize is represented by__________

(a) Hysteresis curve (b) Hysteresis loop area

(c) Hysteresis loop (d) Straight line

(39) In simple cube, one atom or molecule lies at its

(a) force corners (b) nine corners

(c) eight corners (d) six corners

(40) The bulk modulus is a proportionality constant that relates the pressure acting on an object to:

(a) the fractional change in volume (b) the shear

(c) the fractional change in lengt (d) the spring constant

Chapter 18

ELECTRONICS

KIPS

(I) P – N junction

- Diodes
  - Forward biased
  - Reverse biased
- LED
- Photo diode
- Photo voltaic cell

(II) Rectification

- Half wave rectification
- Full wave rectification

(III) Transistor

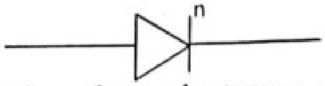
- Transistor as an amplifier
- Transistor as a switch
- Operational amplifier
  - Inverting amplifier
  - Non – inverting amplifier
- OP – Amp as Comparator
- Comparator as a night switch

(IV) Digital System

- Logic Gates
- OR gate
- NOT gate
- AND gate
- NOR and NAND gate
- Exclusive NOR and OR gate

p-n JUNCTION AND ITS CHARACTERISTICS

A p-n junction is formed when a crystal of **germanium** or **silicon** is grown in such a way that if one half of crystal is doped with a **trivalent impurity** and the other half with **pentavalent impurity**



- Its n-region contains free electrons as majority charge carriers and p-region contains holes as majority charge carriers.
- In N-region the minority charge carriers are holes while electrons are minority charge carriers in case of P-region.
- Just after the formation of the junction, the free electrons in the n-region because of their random motion diffuse into p-region. As a result, a charge less region is formed around the junction in which charge carriers are not present. This region is known as *depletion region.*

> **Do you know?**
> An extrinsic semi conductor i.e. a semi conductor after doping still remains electrically neutral whether it is p-type or n-type

FORWARD BIASED p-n JUNCTION

When an **external** potential difference is applied across a p-n junction such as p-side is connected with positive and n-side with negative terminals of the battery.

- The external potential difference supplies energy to free electrons and holes in the n-region and p-region respectively. When this energy is sufficient to overcome the **potential barrier**, a current of the order of a few mili-amperes begins to flow across the p-n junction. In this state, p-n junction is said to be ***forward biased.***
- If for ward bias voltage is increased by ΔV_f, the current increases by ΔI_f. The ratio $\frac{\Delta V_f}{\Delta I_f}$ is known as ***forward resistance*** *of the p-n junction.* i.e.

$$r_f = \frac{\Delta V_f}{\Delta I_f}$$

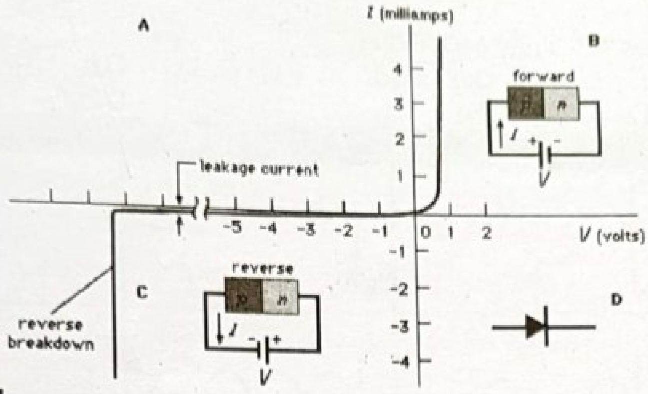
For your information

The forward biased barrier potential for silicon is 0.7V while for Germanium is 0.3V.

REVERSE BIASED p-n JUNCTION

When the external source of voltage is applied across a p-n junction such that its positive terminal is connected to n-region and its negative terminal to p-region

- In reverse biased situation, no current flows due to the **majority charge carriers.** However a very small current, of the order of few micro amperes, flows across the junction due to flow of minority charge carriers, known as *reverse current or leakage current.*
- Leakage current increases with increase in voltage.
- At a certain high voltage the reverse current increases sharply. This voltage is called break down voltage.



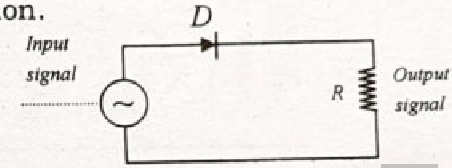
For your information

The leakage current for Ge is in amperes while for silicon it is in microamperes.

RECTIFICATION

Conversion of alternating current into direct current is called rectification.

- There are two very common types of rectification.



Half-wave rectification (HWR)

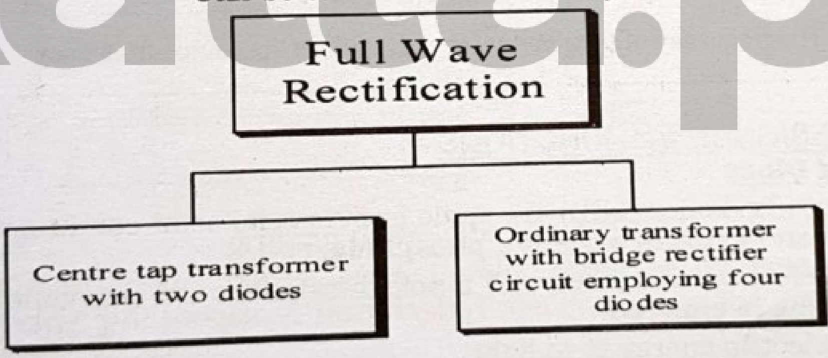
- One diode is used.
- For upper half or lower half is rectified.
- Can be used for charging battery.

Draw Backs

- More pulsations in the output wave form.
- Average value of the out put DC signal drops.

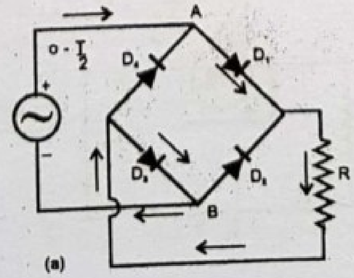
Full wave Rectification (FWR)

Can be carried out in two ways



Bridge Rectifier

- Four diodes are used.
- Two diodes remains ON (FWD Biased) in each half of the input cycle while other two remains off (Reverse Biased) in the same half o the cycle.



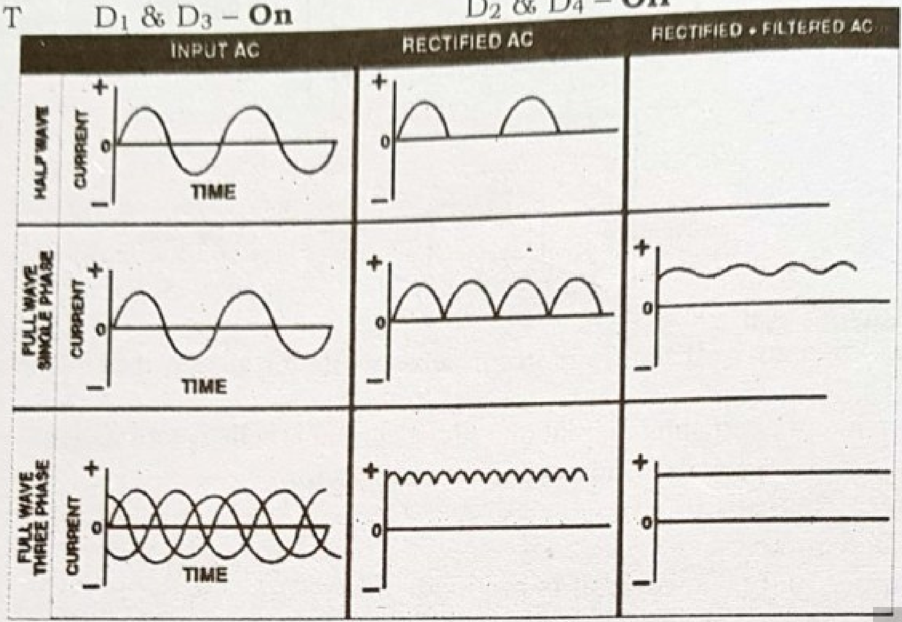
(a)

Summary

If input wave has "T" Time period then

O ~ T/2 D_1 & D_3 – **Off and** D_2 & D_4 – **On**

T/2 ~ T D_1 & D_3 – **On** D_2 & D_4 – **Off**



Advantages

- Very inexpensive method of rectification.
- Average values do not drop significantly.
- Lesser pulsations are there in the signal compared to HWR.

Do you know?

The frequency of the FWR wave is two times the source frequency

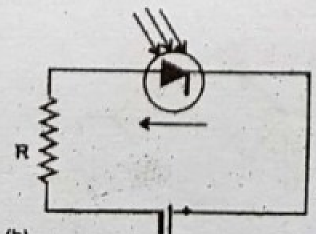
SPECIALLY DESIGNED p-n JUNCTIONS

Light Emitting Diode

- Light emitting diodes (LED) are made from special semi-conductors such as **gallium arsenide** and **gallium arsenide phosphide**.
- When an electron combines with a hole during forward bias conduction, a photon of **visible light is emitted**..
- Convert Electric energy in to light

Photo Diode

- Photo diode is used for **detection of light**.
- A photo diode can turn its current **ON** and **OFF** in nano seconds.
- Photo diode is fastest photo detection device.



(b)

Do you know?

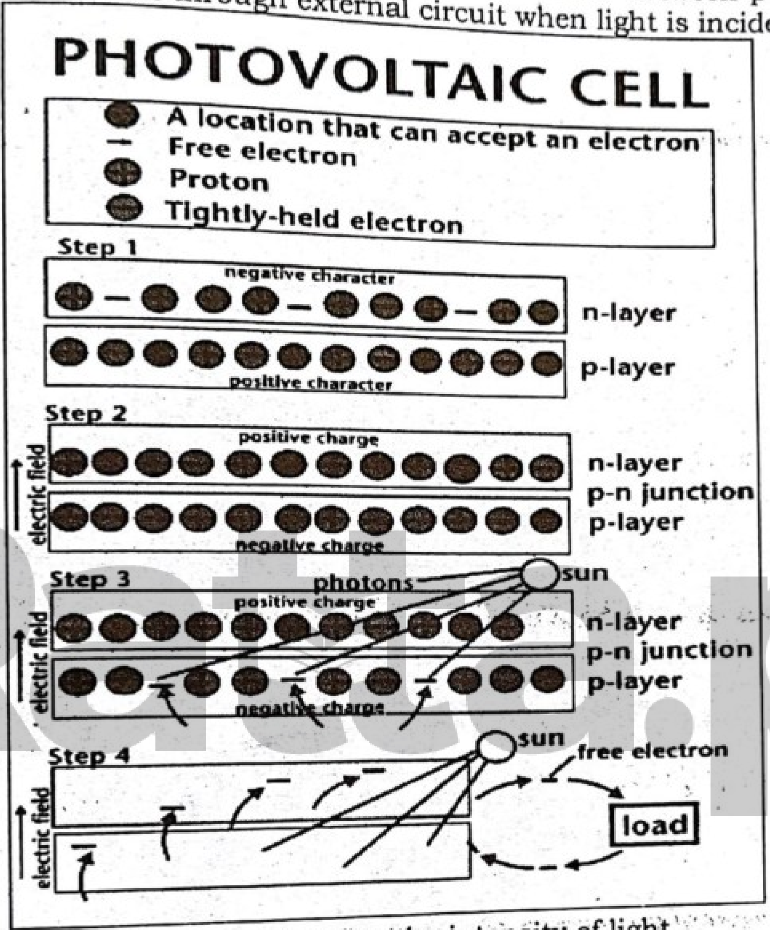
The photo diode is operated in reverse biased region

Applications

(i) Detection of both visible and invisible spectrums
(ii) Automatic switching.
(iii) Logic circuits.
(iv) Optical

Photovoltaic Cell

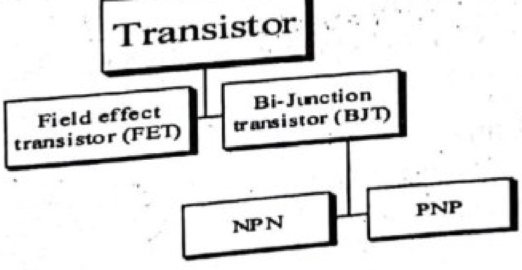
- Such cells are p-n junction in which potential barrier between p and n regions is used to drive a current through external circuit when light is incident on junction.



- The current is directly proportional to the intensity of light.
- In order to obtain greater power, series-parallel arrays of thousands of such cells are used forming ***photovoltaic panels*** and are commonly used in satellites and space stations.

TRANSISTORS

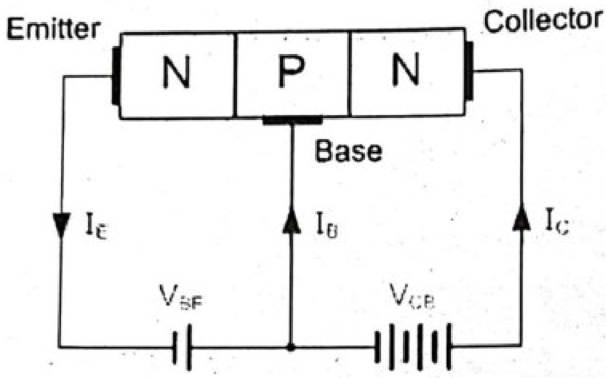
An active component of an electronic circuit consisting of a small block of semi-conducting material to which at least three electrical contacts are made.

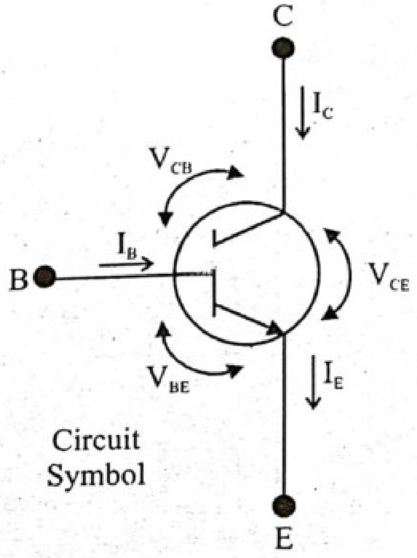


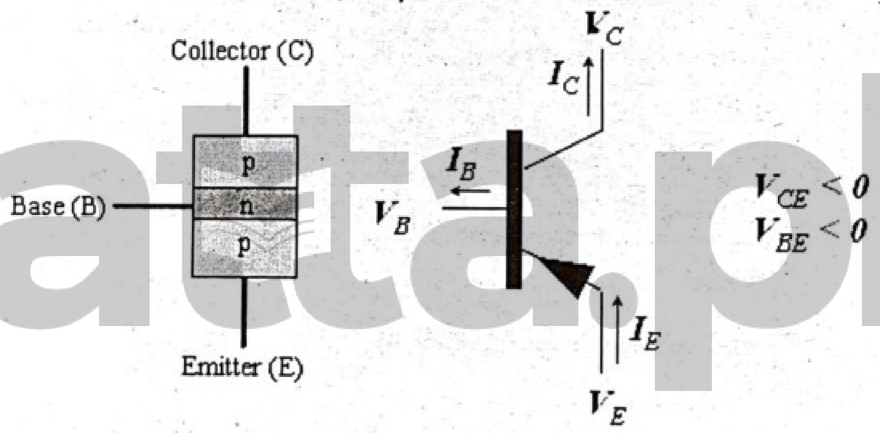
Types of Transistors

***n-p-n* transistors**

A transistor in which ***p-type*** *material is* ***sandwiched*** *between two n-type materials is known as n-p-n transistor.*







Terminals Of Transistors

Emitter: It provides majority carriers for current flow

Base: It controls the current between emitter & base.

Collector: It collects the emitted majority carrier from circuit operation.

The emitter has greater concentration of impurity as compared to the collector. Collector is physically larger than emitter.

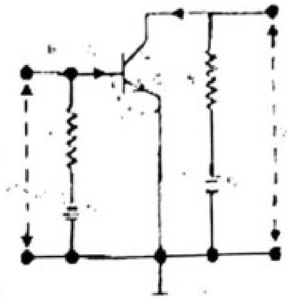
Current Flow in n-p-n Transistor

- Emitter base junction is forward biased.
- Emitter injects a large number of electrons in base region.
- $I_E = I_C + I_B$, $I_B << I_c$

Transistor gain of current $(\beta) = \dfrac{I_C}{I_B}$

Transistor as an Amplifier

- A junction transistor in the **common emitter** mode can act as a voltage amplifier, if a suitable resistor, called a *load* is **connected in the collector** circuit.
- $$\frac{V_{out}}{V_{in}} = \beta\left(\frac{R_C}{r_{ie}}\right)$$
  r_{ie} = in put emitter resistance
- The ratio of $\frac{V_{out}}{V_{in}}$ is called ***voltage gain of the amplifi***

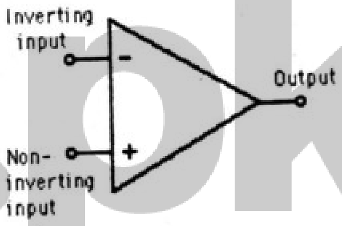


Transistor as a Switch

- Transistors are used as switches in many important ele
- In order to turn on the switch, a large potential V_B is applied between control terminals.
- An electronic computer is basically vast arrangement of electronic switches, which are made from **transistors**.

OPERATIONAL AMPLIFIER

- An operational amplifier is so called because it can perform **electronically**.
  The term operational amplifier or "op-amp" refers to a class of high-gain DC coupled amplifiers with two inputs and a single output. The modern integrated circuit version is typified by the famous 741 op-amp. Some of the general characteristics of the IC version are:



- High gain, on the order of a million
- High input impedance, low output impedance
- Used with split supply, usually +/- 15V
- Used with feedback, with gain determined by the feedback network.

CHARACTERISTICS OF OPERATIONAL AMPLIFIER

High input resistance

- ✦ It is resistance between the (+) and (–) inputs of the amplifier. Its value is very high of the order of several mega ohms.
- ✦ No current flows between two inputs.

Low Output resistance

- ✦ It is the resistance between the output terminal and ground.
- ✦ Its value is only few ohms

High voltage gain

- ✦ It also called open loop gain denoted by A_{OL}

$$Gain = \frac{V_o}{V_+ - V_-} \qquad A_{OL} = \frac{V_o}{V_i}$$

- ✦ The open loop gain for amplifier is very high ~10^5.

OP-AMP AS INVERTING AMPLIFIER

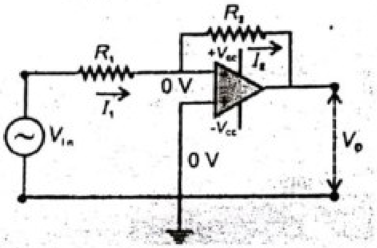
- The non-inverting terminal (+) is grounded; its potential is zero

$I_1 = \frac{V_i}{R_1}$ and $I_o = -\frac{V_o}{R^2}$

- No current flows between (+) and (-) terminals. Therefore, by Kirchhoff's rule.

$I_1 = I_2$

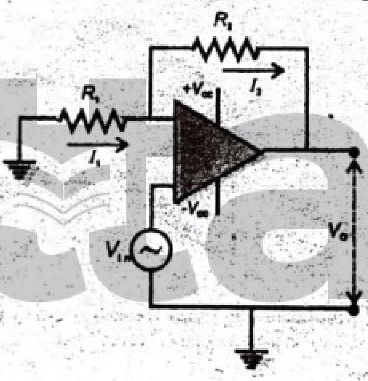
$\frac{V_i}{R_1} = -\frac{V_o}{R_2}$ $\qquad -\frac{R_2}{R_1} = \frac{V_o}{V_i}$



- Signal is inverted
- Gain is defined as the ratio of output voltage to input voltage. $G = -\frac{R_2}{R_1}$

OP-AMP AS NON-INVERTING AMPLIFIERS

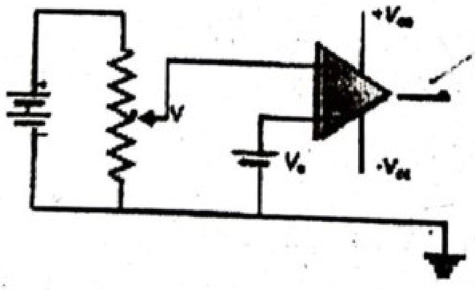
- In this case the input signal V_i is applied at the non-inverting terminal (+).



Gain only depends upon values of R_2 and R_1 and is independent of the open loop gain of the OP-AMP.

OP-AMP AS A COMPARATOR

- OP-AMP usually requires two power supplies of equal voltage, but of opposite polarity.
- Most OP-AMP operate with $V_{CC} = \pm$**12V supply**.



COMPARATOR AS A NIGHT SWITCH

- WHEN INTENSITY OF LIGHT FALLS BELOW A CERTAIN LEVEL, THE STREETLIGHT IS **AUTOMATICALLY SWITCHED** ON. THIS CAN BE ACCOMPLISHED BY USING OP-AMP AS A COMPARATOR.

$$V_R = \frac{R_2}{R_1 + R_2} \times V_{CC}$$

LDR IS LIGHT DEPENDENT RESISTANCE

$$V' = \frac{R_3}{R_L + R_3} \times V_{CC}$$

V' provides the voltage to (–) input of OP-AMP.

At Daytime

$V' > V_r$

and $V_o = -V_{cc}$

Light switched off

At Night

$V' < V_r$

$V_o = +V_{cc}$

Light switched on

LOGIC GATES

- Logic gates are building blocks of a digital system. A logic gate is a digital circuit which is based on certain logic relationship between the input and output voltage of the circuit. That is, a logic gate gives an output for various combinations of the inputs. The logic gates are built using the semiconductor diodes and transistors. There are three basic logic gates. They are:

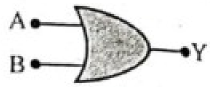
(a) **OR** gate (b) **AND** gate (c) **NOT** gate.

BOOLEAN ALGEBRA

George Boolean developed an **"Algebra of logic"** which is called **"Boolean Algebra'.** The main feature of this algebra is that it permits only two values or states for its variables. These two states may be **"true"** and **"false"** in the logic, **"on"** and **"off"** in electronic circuit but in mathematical way these are **"0"** and **"1"**. Thus each Boolean variable can assume only values 0 or 1.

OR GATE

- OR gate is device that combines A with B to give Y. the OR gate has two (or more) inputs and one output.
- The symbolic representation of a two input OR gate is shown in figure.



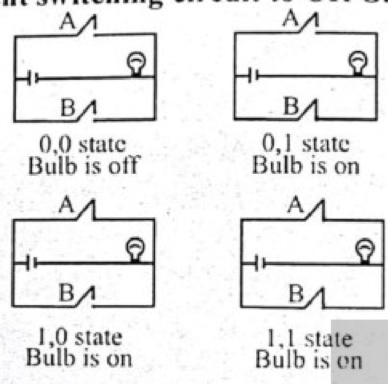
A+B = Y

- These variables A, B and Y have only one of the two values, i.e., either 0 or 1. The OR gate has an output 1 when either A or B or both A and B are 1. Obviously the output would be 0 if both inputs are 0.
- The OR gate in terms of Boolean expression is A + B = Y read as "A OR B equal Y" The meaning of this equation is that Y is true when either A is true or B is true or both are true.
- A table which gives the output states for all possible inputs.

TRUTH TABLE

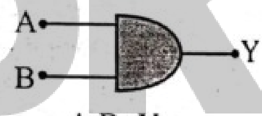
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

Equivalent switching circuit to OR Gate



AND GATE

- The AND gate is circuit which provides an output when all the inputs are simultaneously present.
- The symbolic representation of a two input AND gate is shown in figure.



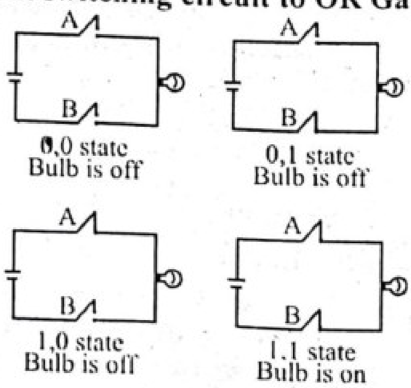
A.B=Y

- The AND circuit has two (or more inputs and one output. Here also the two inputs have been marked as A and B while output as Y, A, B and Y are Boolean variables, i.e., having only two values, i.e., either 0 or 1. The AND gate has an output 1 when its both A and B are 1.
- The AND gate in terms of Boolean expression is A.B = Y read as "A AND B equals to Y".
- The logical meaning of this equation is that Y is true when both A and B are true.

TRUTH TABLE

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Equivalent switching circuit to OR Gate



NOT GATE OR INVERTOR

- The NOT circuit has one input and one output. It is also called NOT gate because output is not the same as its input. It inverts the polarity of the pulse applied to it. Thus NOT circuit negates the input function.
- The symbolic representation of the NOT gate is as shown in figure.
- When A is 0, Y is 1 when A is 1, Y is 0.

$Y = \overline{A}$

- In Boolean algebra, the bar symbol (–) is referred as NOT. The Boolean expression $\overline{A} = Y$ reads "NOT A equals to Y". It implies that Y is negation (or inversion) of A.

TRUTH TABLE

The NOT truth Table

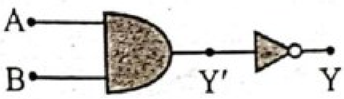
A	Y
0	1
1	0

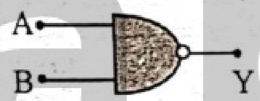
THE NAND GATE

- It is combination of AND gate and NOT gate. If the output Y' of AND gate is connected to the input of NOT gate, the resulting gate is called NAND gate. The Boolian expression for NAND gate is $Y = \overline{A.B}$

Combination of AND gate and NOT gate

A	B	$Y' = A.B$	$Y = \overline{A.B} = \overline{Y'}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0



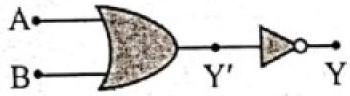


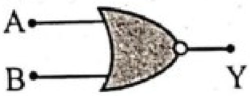
NOR GATE

- The NOR gate is a combination of OR gate and NOT gate. If the output Y' of OR gate is connected to the input NOT gate, the resulting gate is called NOR gate. The Boolian expression for NOR gate is $Y = \overline{A + B}$

Combination of AND gate and NOT gate

A	B	$Y' = A + B$	$Y = \overline{A + B} = \overline{Y'}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0





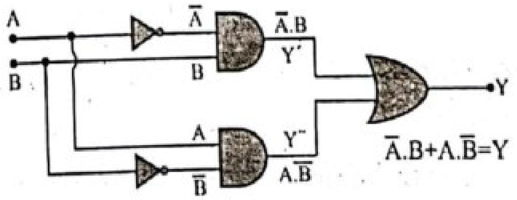
EXCLUSIVE OR GATE (XOR)

- The output of the exclusive – OR Gate is 1 if its either input, but not both is 1. Which means that when the two input are different (one is 0 and the other 1) the output is 1.

$$Y = \overline{A}.B + A.\overline{B}$$

INPUT		OUTPUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

$\overline{A}.B+A.\overline{B}=Y$



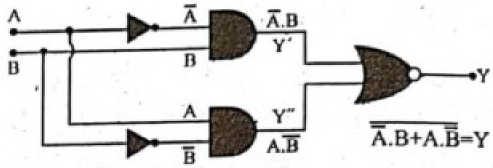
Note: *This circuit is also called an "inequality operator or detector because it produces output only when the two inputs are different.*

EXCLUSIVE NOR GATE (XNOR)

- The exclusive NOR gate, abbreviated as Ex-NOR, operates exactly opposite to Ex-abbreviated as Ex-NOR, operates exactly opposite to Ex-OR gate

$$Y = \overline{\overline{A}.B + A.\overline{B}}$$

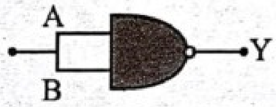
INPUT		OUTPUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1



GATE AS BUILDING BLOCK IN DIGITAL CIRCUITS

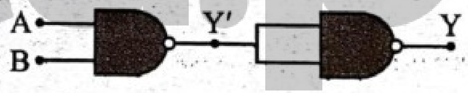
- Repeated use of any of the basic gates (OR, AND and NOT) alone does not produce a different gate. However, the repeated use of NAND (or NOR) gate can produce all the three basic gates. Hence, the NAND (or NOR) serves as a building block in digital circuits.
- **To obtain NOT gate from NAND gate:** When the two inputs A and B of the NAND gate are joined together to make one input, then NAND gate works as NOT gate, using A = B in the truth table of NAND gate we get the truth table of NOT gate.

A	B = A	Y
0	0	1
1	1	0



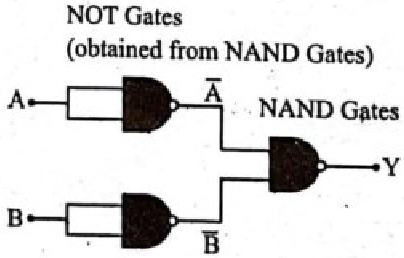
- **To obtain AND gate from NAND gate:** When the output Y′ of the NAND gate in connected to the input of the NOT gate (made from NAND gate by joining its two inputs together), the combination functions as an AND gate. Negation of last column of the truth table of NAND gate gives the truth table of AND gate, provided we read columns A, B and Y only.

A	B	Y′	Y
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1



- **To obtain OR gate from NAND gate:** When the two inputs of a NAND gates are joined together, it works as a NOT gate. Now, if the inputs A and B are inverted by using two NOT gates (obtained from two NAND gates) and the resulting outputs $\overline{A}$ and $\overline{B}$ are fed into a third NAND gate, then the arrangement works as an OR gate.

A	B	$\overline{A}$	$\overline{B}$	Y
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1



- The construction of the truth table of this arrangement is explained. The columns $\overline{A}$, $\overline{B}$ and Y of this table form the truth table of a NAND gate. The truth table of OR gate is obtained by reading A, B and Y only.

PRACTICE EXERCISE

30 mins Time Yourself

(1) **In p-type semiconductor the majority and minority charge carriers are**
(a)holes and electrons
(b)electrons and holes
(c)electrons and proton
(d)holes and protons

(2) **Semi-conductors with donor atoms and free electrons belong to the type ______**
(a)N
(b)P
(c)mix
(d)any of above

(3) **Diode can work as**
(a)oscillator
(b)transformer
(c)generator
(d)rectifier

(4) **Acceptor and donor impurities donate______________**
(a)n-carriers only
(b)p-carriers only
(c)p-carriers and n- carriers respectively
(d)n-carriers and p-carriers respectively

(5) **p-n junction when reversed biased acts as a ____________**
(a)capacitor
(b)inductor
(c)on switch
(d)off switch

(6) **In p-n-p transistor, the collector current is ____________**
(a)equal to emitter current
(b)slightly less than emitter current
(c)greater than emitter current.
(d)any of above

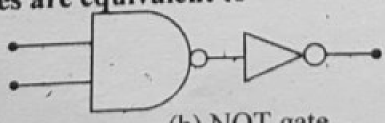
(7) **In n-p-n transistor, p works as ___________**
(a)collector
(b)emitter
(c)base
(d)any of above

(8) **The simplest type of rectification known as half wave rectification is obtained by ___________**
(a)using a transistor
(b)suppressing the harmonics in A.C voltage
(c)suppressing half wave of A.C supply by using diode
(d)using a Coolidge tube

(9) **Identify the correct statement about minority carriers-**
(a)holes in n-type and free electrons in p-type
(b)holes in n-type and p-type
(c)free electrons in n-type and holes in p-type
(d)free electrons in n-type and p-type

(10) **Depletion region of a junction is formed_________________**
(a)during the manufacturing process
(b)under forward bias
(c)under reverse bias
(d)when temperature varies

(11) **The combination of these gates are equivalent to**



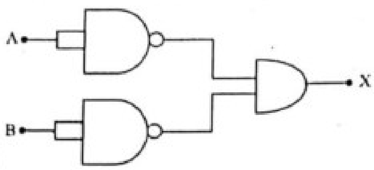
(a) NAND gate
(b) NOT gate
(c) AND gate
(d) XNOR gate

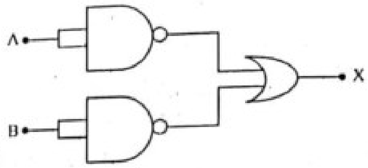
(12) **On increasing the reverse bias to a large value in a pn junction diode, the current**
(a) increases slowly
(b) remains fixed
(c) increases suddenly
(d)decreases slowly

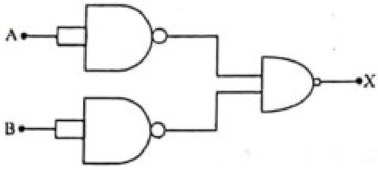
(13) **Which one of the following has the greatest energy gap?**
(a)insulator
(b)conductor
(c)semi conductor
(d)all of above

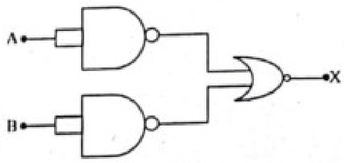
(14) **The value of resistivity for conductor is of the order of _________**
(a)10^{-5} ohm metre
(b)10^{-6} ohm metre
(c)10^{-7} ohm metre
(d)10^{-8} ohm metre

(15) Which of the following will represent OR gate

(a)


(b)


(c)


(d)


(16) Hole is equivalent to ____________

(a) a positive charge
(b) a negative charge
(c)a neutral particle
(d)an electron

(17) Which one of the following is not a donor impurity?

(a)antimony
(b)phosphorus
(c)aluminium
(d)arsenic

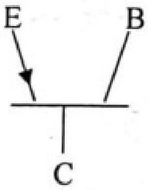
(18) Forward current through a semi conductor diode circuit is due to ____________

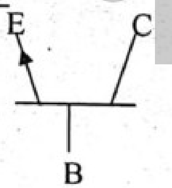
(a)minority carriers
(b)majority carriers
(c)holes
(d)electrons

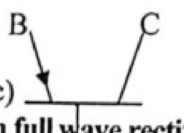
(19) In the transistor schematic symbol, the arrow ____________

(a)is located on the emitter
(b)is located on the base
(c)is locate on the collector
(d)points form north to south

(20) The symbol of n-p-n transistor is ____________

(a)


(b)


(c)


(d) none of these

(21) In full wave rectification, the output D.C. voltage across the load is obtained for ____________

(a) The positive half cycle of input A.C.
(b) The negative half cycle of input A.C.
(c) The complete cycle of input A.C.
(d) All of the above.

(22) **The semiconductor diode can be used as a rectifier because ______________**

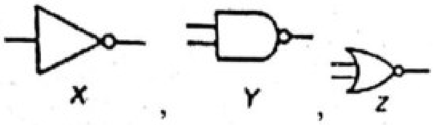
(a) It has low resistance to the current flow when forward biased & high resistance when reverse biased.

(b) It has low resistance to the current flow when forward biased.

(c) It has high resistance to the current flow when reverse biased.

(d) Its conductivity increases with rise of temperature.

(23) **Diagram shows three logic gates X, Y and Z.**



Which of the following is correct about the names of the three logic gates?

	X	Y	Z
(a)	NAND	NOR	NOT
(b)	NOT	NAND	NOR
(c)	NOR	AND	NOT
(d)	NAND	NOT	NOR

(24) **The device or circuit used for conversion of A.C. into D.C. is called ______**

(a) An amplifier.
(b) A rectifier
(c) Filtering circuit
(d) Converter.

(25) **The device used for conversion of D.C. to A.C. is called ________**

(a) Converter
(b) Amplifier
(c) Inverter
(d) Oscillator

(26) **The specially designed semiconductor diodes used as indicator lamps in electronic circuits are ______**

(a) The switch
(b) The light emitting diode
(c) The photo diodes
(d) Solar cells.

(27) **The specially designed semi-conductor diodes used as fast counters in electronic circuits are ______**

(a) The light emitting diodes
(b) Photo diodes
(c) Photo voltaic cell
(d) Solar cells.

(28) **The alternating voltage is an example of ______**

(a) A digital waveform
(b) An analogue waveform
(c) Discrete waveform
(d) None at all

(29) **For amplification by a transistor the signal to be amplified is connected between the**

(a) emitter and collector
(b) emitter and base
(c) base and collector
(d) any of the above

(30) **AND operation can be represented by**

(a) Two switches in series
(b) Two switches in parallel
(c) Both "a" and "b"
(d) None of these

(31) **NAND gate is a combination of**

(a) AND gate and NOT gate
(b) AND gate and OR gate
(c) OR gate and NOT gate
(d) NOT gate and NOT gate

(32) To obtain an n-type semiconductor germanium crystal, it must be doped with foreign atoms whose valency is

(a) 2 (b) 3

(c) 4 (d) 5

(33) The gate which changes the logic level to its opposite level

(a) NOR gate (b) NOT gate

(c) NAND gate (d) Any of these

(34) $X = \overline{A\overline{B} + \overline{A}B}$ is Boolean expression for

(a) OR g (b) X NOR gate

(a) NAND gate (d) X-OR gate

(35) In forward bias the width of potential barrier

(a) Increases (b) Decreases

(c)Remains same (d) No effect

(36) For the manipulation of the quantities, which have values 1 and 0, special algebra is used called:

(a) Simple Algebra (b) Newton Algebra

(c) Leibnitz Algebra (d) Boolean algebra

(37) The electronic circuits which implement the various logic operations are called

(a) Logic gates (b) Boolean algebra

(c) Amplifier gain (d) Logic functions

(38) An OP-AMP as a comparator is a circuit that compares the signal voltage on one of its inputs with a

(a) Non-inverting voltage at output (b) Reference voltage on the other

(c) Virtual input (d) Output

(39) An OP-AMPs can amplify

(a) D.C. (b) A.C.

(c) Both A.C. & D.C. (d) None of the above

(40) Non-inverting amplifier circuits have

(a) A very high input impedance (b) A very low input impedance

(c) A low output impedance (d) None of the above

(I) Modern Physics

- Relative Motion
- Frame of reference
- Inertial frame of reference
- Non – inertial frame of referee
- Special Theory Relativity
- Time Dilation
- Length Contraction
- Mass variation
- Energy – mass relation

(II) Black Body Radiation

- Stefen's constant
- Plank assumption
- Photon
- Einstein's extended idea

KIPS

(III) Interaction of E.M relation with nolter

- Photo electric effect
- Photo cells
- Compton's effect
- Annihilatoin of matter

(IV) Wave nature of particle

- Davisson and Germer experiment
- Wave particle duality
- Electron Microscope
- Uncertainty Principle

PHYSICS

Classical Physics | Modern Physics

CLASSICAL PHYSICS	MODERN PHYSICS
It is based upon classical mechanics or Newtonian mechanics	It is based upon quantum mechanics
It consists of Newton's laws of motion and other laws dealing at macroscopic level. It deals at ordinary everyday life.	It is a discipline of laws of physics that deals at microscopic level as well as macro levels if car is consider as special case.
Span of classical physics include; (i) Newton's three laws of motion. (ii) Newton's law of gravitation. (iii) Four laws of thermodynamics. (iv) Gas laws. (v) Maxwell's equation of e.m waves.	Span of modern physics includes; (i) Michelson's and Morley's findings. (ii) Schiodinger wave equations. (iii) De-Broglie hypothesis. (iv) Bohr's ideas. (v) Heisenberg's uncertainty principle. (vi) Plank's theory. (vii) Special theory of relativity (viii) General theory of relativity.

IDEAS OF MODERN PHYSICS

- Light is an electromagnetic wave
- Light consists of **photons**, each having energy $E = hf$
- Speed of light is a universal constant in vacuum that is independent of motion of source and observers.
- Absorption and emission of electromagnetic waves takes place in the form of packets of energy called **photons.**
- True laws of physics retain their mathematical form in all **inertial frame of reference.**
- All motions and rest are **relative.**
- There is nothing like **absolute rest** or motion.
- Wave - particle duality.
- Reaction takes some time to replay, after action.
- Matter waves are associated with moving particles.
- Einstein Equation's Energy mass relation is $\mathbf{E = mc^2}$
- Photon is splitted into a pair of electron and positron, process called **pair production.**
- Positron and electron are **annihilated to photon**.
- Position, momentum, energy and time can't be measured accurately at same time.

RELATIVE MOTION

- The concept of **direction** is purely relative.
- The experiments give same results in same frame of reference. In different frames, give different results.

FRAME OF REFERENCE

The coordinate system x, y and z axes from where observation is made is called frame of reference.

- ***Inertial frame*** is that either it is at rest or moving **with uniform** velocity.
- ***Non inertial frame*** is that which is in accelerated motion.
- Earth may be considered as an inertial frame of reference for motion on Earth.

Do you know?

The frame of reference in which the law of inertia is valid is called as inertial frame of reference.

THEORY OF RELATIVITY

- **In 1905,** Einstein put forward his theory of relativity.
- Special theory of relativity deals with inertial frames of reference.

Important Results of Special Theory of Relativity

- $m = \dfrac{m_o}{\sqrt{1-\dfrac{v^2}{c^2}}}$
- $l = l_o\sqrt{1-\dfrac{v^2}{c^2}}$ *(Lorentz Contraction)*
- $t = \dfrac{t_o}{\sqrt{1-\dfrac{v^2}{c^2}}}$ where v = relativistic speed
- $E = mc^2$
- All motions and rest are relative.
- No body moves with velocity **greater** than velocity of light.

For your information

At ordinary speed (as in common life) the results of special theory of relativity are

$m = m_o$

$\ell = \ell_o$ as $v \approx c$

$t = t_o$

that is why we don't observe any change in length, mass and time in ordinary life.

NAVSTAR NAVIGATION SYSTEM

- Modern system of navigation satellites called **NAVSTAR** use results of **special theory of relativity**.
- The location and speed anywhere on the Earth can be measured accurately up to 50m after 1hr flight and **2cms^{-1}** velocity with use of NAVSTAR.

BLACK BODY RADIATION

Black body is an ideal ***radiator*** *and ideal* ***absorber.***

- The emissive or absorptive power is **1.**
- Black body is very bad reflector
- Black body emits electromagnetic waves

Intensity Distribution of Black Body

- ***Lummer*** *and* ***Pringsheim*** measured the intensity of emitted energy of different wavelengths.
- Curve shows the characteristics depending upon temperature.
- At a given temperature, the energy is not uniformly distributed in the **radiation** spectrum.

- $\lambda_{max} \times T$ = constant = 2.9×10^{-3} m K so, $T \propto \frac{1}{\lambda}$
- The area under the curve shows total amount of energy i.e. **emissive power.**
- Energy (area of curve) is directly proportional to the fourth power of Kelvin temperature i.e. ***Stephen- Boltzman law* is E α T⁴**

$$E = 6T^4$$

$$6 = 5.67\times10^{-8}\ Wm^2K^{-4} = \textbf{Stephen's constant}$$

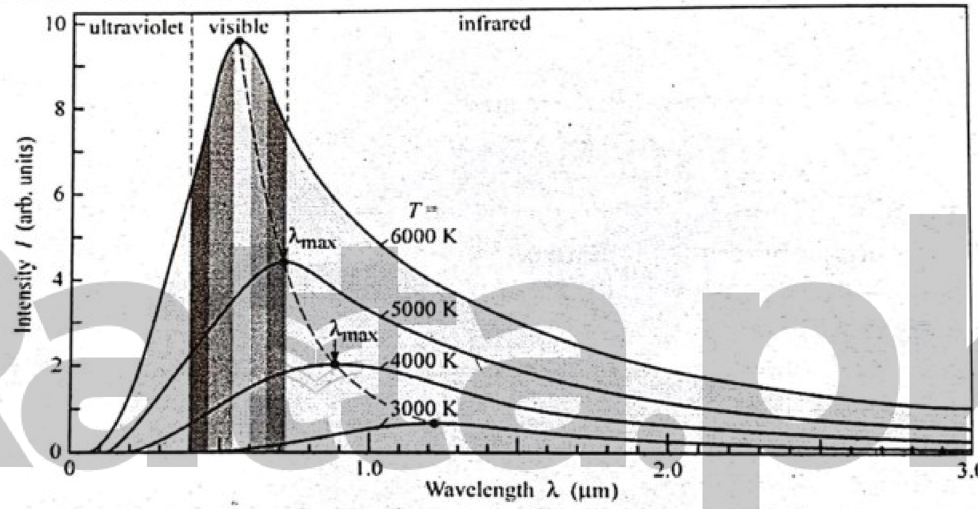
- Shape of black body radiation curve is same and independent of material of the body.
- Classical attempts for explanation of black body radiations are given below.

✦ ***Wein's** Displacement law* holds good for **shorter wavelength**.

✦ ***Rayleigh** Jeans law* holds good at **longer wavelength.**

✦ *Plank's quantum theory* explains the black body radiations that absorption and emission of radiation takes place in the form of packets of energy called quanta i.e. E = hf. *It holds good at all **wavelengths.***

✦ *Max Plank receive noble prize in 1918 in physics for discovery of energy quanta .*



THE PHOTONS

- *Einstein presented the idea of light energy consisting of packets of **electromagnetic** energy.*
- Max plank explained the emission and absorption by the atoms from a black surface is in the form of indivisible packets called **quanta.**
- *Max plank put discontinuous **(granular)** nature of light.*
- The beam of light with wavelength λ consists of stream of photons traveling at speed c and carrier energy hf.
- As $E = mc^2$ and $E = hf$

then $mc^2 = hf$

or $mcc = hf$

$$mc = \frac{hf}{c}$$

As $mc = p$ and $f = \frac{c}{\lambda}$ P = momentum

then $p = \frac{h}{\lambda}$

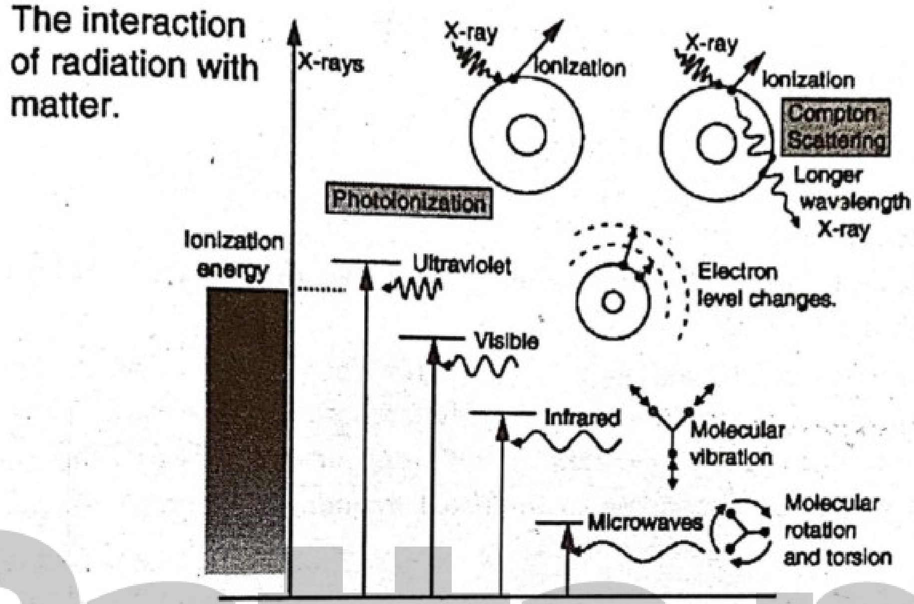
- Emission or absorption of energy is applied to any **oscillating system.**

INTERACTION OF ELECTROMAGNETIC RADIATION WITH MATTER

It is of three types depending upon the energy of photon.

- Photo electric effect — $hf<0.1MeV$
- Compton effect — $0.1MeV<hf<1MeV$
- Pair production — $hf>1MeV$

For your information



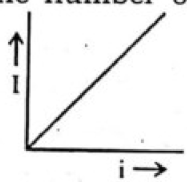
PHOTOELECTRIC EFFECT AND PHOTON THEORY OF LIGHT

- When light is incident on the surface of a metal electrons are emitted from it. This phenomenon is known as "Photoelectric effect."
- The photoelectric effect supports the quantum nature of light.
- Emitted electrons are known as photoelectrons.
- This effect is based on the principle of energy conservation.
- Photoelectric effect was first explained by Einstein for which he was awarded Nobel Prize in the year 1921.

Study of Photoelectric Effect: **The emission of electrons from metallic surface, when light of specific short wavelength is incident on it is called "Photoelectric effect".** Hallwach applied some potential difference across two Zn plates in a quartz vacuum tube and studied the flow of current. When ultraviolet light is incident on cathode current flows in the circuit which vanishes when no light falls. When light falls on anode the current in the circuit is negligible.

Effect of Intensity of incident light on photoelectric current: When the intensity of light of frequency more than the threshold frequency is increased the number of photoelectrons increase i.e., the photoelectric current also increase.

Photoelectric current, $i \propto I$ where **I = Intensity of light**



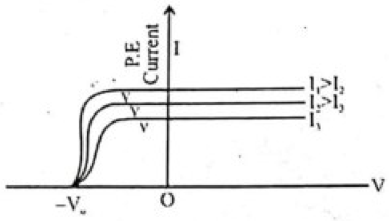
Effect of potential on photoelectric current:

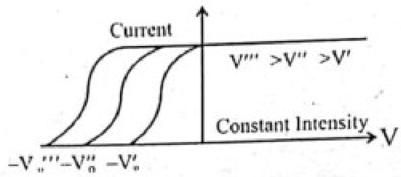
- On increasing the potential current first increases and at a fixed potential reaches a maximum value known as saturation current.
- At a fixed negative potential the value of photoelectric current is zero. This negative potential is called stopping potential.
- The stopping potential is proportional to the maximum kinetic energy of photoelectrons.
- The stopping potential depends on the frequency of the incident light.
- The stopping potential does not depend on the intensity of the Incident light.

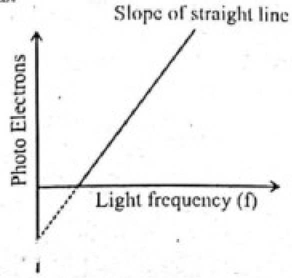
Effect of frequency of incident light on photoelectric current:

A simple linear relation exists between stopping potential (maximum energy of emitted electron) and frequency of incident photon.

$hf = eV + \phi_o$ or $hf = K.E + \phi_o$ or $\phi_o = hf - K.E_{max}$







Laws of Photoelectric Effect:

- The rate of emission of photoelectrons from a metallic surface is proportional to the intensity of incident light.
- If the frequency of incident light is less than a specific minimum (whatever the intensity of light) electrons will not be ejected from the surface.

  This minimum (threshold) frequency is different for different metals.

  The photo energy corresponding to threshold frequency is known as work function of metal.

$$\phi_o = hf_o = \frac{hc}{\lambda_o}$$

- The maximum K.E. of emitted photoelectrons is proportional (linearly related) to the frequency of incident light but does not depend on the intensity of incident light.
- The time interval of incidence of light on the metallic surface and electron emission is negligible (less than 10^{-8}s). i..e, the process of electron ejection is instantaneous.

Parameters of Photoelectric Effect

- **Work function (ϕ_o):** The minimum energy required to eject an electron from the metal surface is known as its work function. $\phi_o = hf_o$

  (a) It depends upon:

✦ The impurities present on the surface of the metal

✦ The nature of metal

  (b) Its unit are eV, joule and erg.

  (c) It is a property of material and not of emitted electron.

- **Photo sensitive material:** Those elements that eject photons when high frequency light is incident on the material are called photo sensitive material.
- **Saturated photocurrent:** The maximum value of photocurrent is called saturated current.
- Due to stopping potential the work done by electrons is equal to the maximum kinetic energy of electrons.

$$eV_o = \frac{1}{2}mv^2_{max}$$

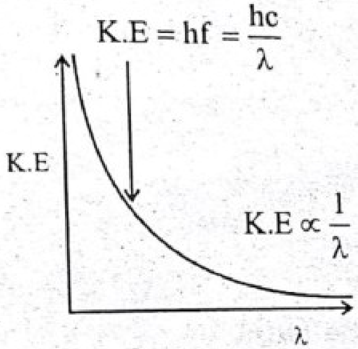
Einstein's Explanation of Photoelectric Effect: Light has dual (wave and particle) nature. In interaction of light with matter light acts as particle. According to quantum theory the exchange or propagation of light is in the form of small energy packets called photons.

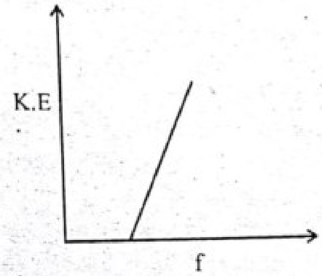
$$E = hf = \frac{hc}{\lambda}$$

Einstein's Photoelectric Equation:

$$K.E_{max} = hf - \phi_o = hf - hf_o \qquad = h(f - f_o) \quad , \quad \frac{1}{2}mv^2_{max} = hf - \phi_o$$

Important Graphs:





Failure of Classical Theory to Explain Photoelectric Effect:

The wave theory of light completely failed to explain the experimentally established facts about photoelectric effect.

- The fact that maximum kinetic energy of photoelectrons does not depend on intensity of incident radiation.
- The existence of a threshold frequency or wavelength.

For your Information

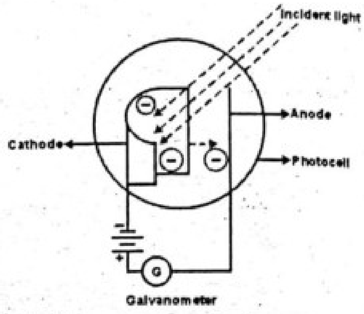
A weak beam of radiations having frequency more than threshold frequency can eject a photo electron while an intense beam of frequency lesser than threshold cannot eject a photo electron.

Phenomenon	Can be explained in terms of waves.	Can be explained in terms of particles.
Reflection	✓	✓
Refraction	✓	✓
Interference	✓	⊗
Diffraction	✓	⊗
Polarization	✓	✓
Photoelectric effect	⊗	

PHOTO CELL

- A photocell is based on **photoelectric effect**.
- *A simple photocell consists of a glass bulb with a thin* ***anode rod*** *and a* ***cathode*** *of an appropriate metal surface.*
- Sodium or potassium cathode surface emits electrons for visible light.
- Cesium coated oxidized silver emits electrons for infrared light.
- Some surface selenium or silicon emits electrons for ultraviolet rays, X-rays and γ-rays.

Applications of photocells



- Security system
- Counting systems
- Automatic door systems
- Automatic street lighting
- Exposure meter for photography
- Sound tracks of movies
- Solar panels in watches and other appliances

COMPTON EFFECT

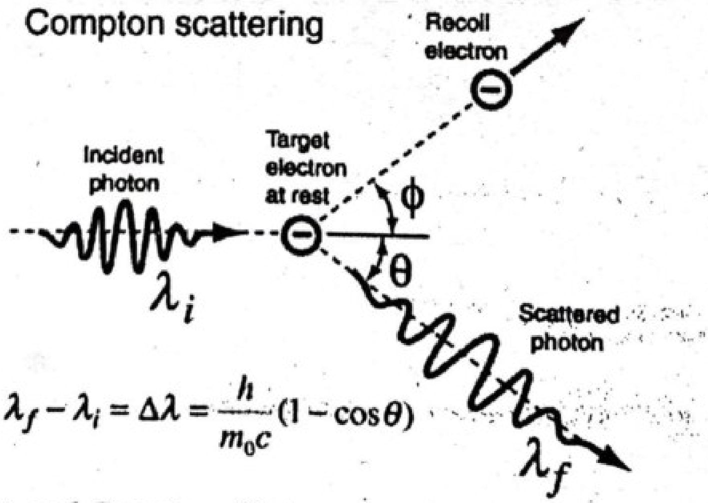
When a photon hits with an electron, it scatters with frequency less than that of incident photon; It is known as **compton effect.**

- *Usually X-ray photons are used because of high energy* ***(≥ 17.5 KeV).***
- Change (increase) in wavelength is called ***Compton shift***.

$$\Delta\lambda = \lambda_f - \lambda_i$$

$$\Delta\lambda = \frac{h}{m_o c}(1-\cos\theta)$$

- $\Delta\lambda = \frac{h}{m_o c} = 2.43 \times 10^{-12}$ m is called ***Compton wavelength***.
- $\Delta\lambda = 0$ when $\theta = 0°$.
- $\Delta\lambda = \frac{h}{m_o c}$ when $\theta = 90°$.
- $\Delta\lambda = \frac{2h}{m_o c}$ when $\theta = 180°$.

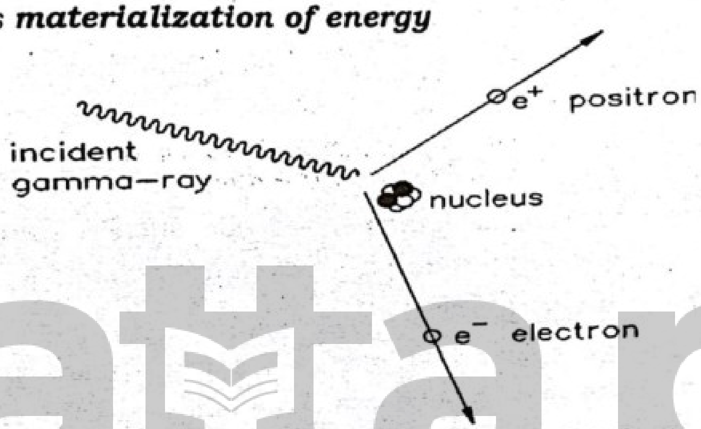


- *Photoelectric effect and Compton effect are strong evidences that e.m waves behave as* ***particle (photon).***

- *Compton effect proves* **photon** *theory of light.*

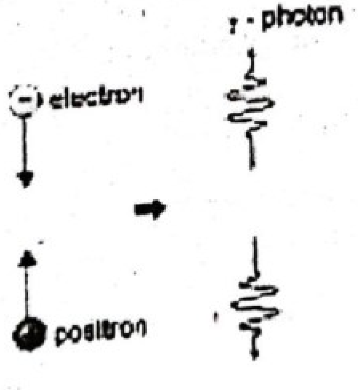
PAIR PRODUCTION

- Decomposition of photon into electron, positron pair is called pair production.
- Pair production can takes place only if photon energy is greater than **1.02 MeV.**
- *Energy equation for pair production* is given as;
- $hf = 2m_oc^2 + K.E_{e-} + K.E_{e+}$
- *Rest mass energy* of electron or positron is $\mathbf{m_oc^2}$ **(= 0.51 MeV).**
- Condition for pair production is that $hf > 2m_oc^2$
- *Pair production can not take place in* ***vacuum***
- *The interaction usually takes place in the electric field in the vicinity of a heavy nucleus so that there is a particle to take up recoil energy and momentum is conserved.*
- *Pair production is* ***materialization of energy***



ANNIHILATION OF MATTER

- *Reverse process of pair production is called* ***annihilation of matter.***
- It involves conversion of mass into energy.
- Two photons are produced by the annihilation of electron and positron
- Two photons produced move in opposite direction to obey the law of **conservation of momentum.**
- Each photon has energy of **0.51Mev** equivalent to rest mass energy of electron.



ANTIMATTER

- ***P.A.M Dirac*** theoretically predicted antimatter in 1928.
- Anderson discovered positron during study of spectrum of cosmic rays in 1932.
- *Every antiparticle has same mass, same spin but opposite magnetic moment and charge to its respective particle.*

PARTICLE	ANTIPARTICLE
Electron	*Positron*
Proton	*Antiproton*
Neutron	*Antineutron*
Neutrino	*Antineutrino*
Earth	*Black hole*

De-BROGLIE'S HYPOTHESIS (Wave particle duality)

All the moving particles behave as waves called matter waves or particle waves. The wave length associated with moving particles is given by

$$\lambda = \frac{h}{mv}$$

mV = momentum of particles

$$\lambda = \frac{h}{p}$$

$$\lambda \propto \frac{1}{m}$$

$$\lambda \propto \frac{1}{v}$$

An object of large mass and ordinary speed has such a small wavelength that its wave effects such as interference and diffraction are negligible.

DAVISSON AND GERMER EXPERIMENT

- ***Germer*** *and* **Davisson** using low energy electron beam provided experimental confirmation of **de-Broglie's hypothesis**. They showed that electrons are diffracted from metal crystals in exactly the dame manner as X – rays or any other wave.
- The electron beam of energy Ve is made incident on a nickel crystal. The beam diffracted from crystal surface. The wavelength associated with the moving electrons is given as:

$$\lambda = \frac{h}{mv}$$

$$mv = \sqrt{2mVe}$$

$$\lambda = \frac{h}{\sqrt{2mVe}}$$ where V is accelerating potential

V = 54v

$$\lambda = 1.66x10^{-10} m$$

- This beam of electrons diffracted from crystal surface was obtained for a glancing angle of 65°. According to Bragg's equation $2d\,sin\theta = m\lambda$

  For 1st order diffracting m = 1

  For nickel d = 0.91×10^{-10}m

  Which gives $\lambda = 1.65 \times 10^{-10} m$
- Prince Louis Victor de Broglie received the 1929 noble prize in physics Clinton Joseph Davisson and George Paget Thomson shared the Nobel Prize in 1937 for their experimental confirmation of the wave nature of particles.
- Electron microscope is a practical application of wave particles duality.

HEISENBERG'S UNCERTAINTY PRINCIPLE

It states that following pairs of quantities can't be measured with perfect accuracy at same time.

- *Linear momentum and position*
- *Energy and time*
- Such quantities are called conjugate quantities.

Mathematically,

$$\Delta p \simeq \frac{h}{\lambda}$$

$$\Delta x \simeq \lambda$$

$$\Delta p \,.\, \Delta x = h$$

$$\Delta E \,.\, \Delta t = h$$

- To increase accuracy in measuring position, we should use short wavelength.
- To increase accuracy in measuring momentum, we should use long wavelength.

IMPORTANT CONSIDERATIONS

- A ball falling freely appears to fall straight to **stationary observer** and falling along curved path to moving observer. It is due to relative motion.
- If $V = 0.999C$ then $m = 22.4\ m_o$
- Millikan determined the values of 'e' and 'h'.
- Human body emits e.m waves in infrared region at only 310K.
- If $V \geq 2.6 \times 10^8$ m/s, then $l = l_o / 2$ & $m = 2\ m_o$

ELECTROMAGNETIC SPECTRUM

S.#	Name	Wavelength Range (Metre)	Frequency Range (Hertz)	How Produced
1.	Gamma rays	6×10^{-13}–1×10^{-10}	5×10^{20}–3×10^{19}	Nuclei of atoms
2.	X-rays	1×10^{-10}–3×10^{-8}	3×10^{19}–1×10^{16}	Bombardment of high Z target by electrons
3.	Ultraviolet rays	3×10^{-8}–4×10^{-7}	1×10^{16}–8×10^{14}	Excitation of atoms and vacuum spark
4.	Visible light	4×10^{-7}–8×10^{-7}	8×10^{14}–4×10^{14}	Excitation of atoms, spark and arc flame
5.	Infrared rays	8×10^{-7}–3×10^{-5}	4×10^{14}–3×10^{13}	Excitation of atoms and molecules
6.	Heat radiation	1×10^{-5}–1×10^{-1}	3×10^{13}–3×10^{9}	Heating
7.	Microwaves	1×10^{-3}–3×10^{-1}	3×10^{11}–1×10^{9}	Oscillating currents in special vacuum tubes
8.	Ultra high radio frequencies	1×10^{-1}–1	3×10^{9}–3×10^{8}	Oscillating circuits
9.	Very high radio frequencies	1 – 10	3×10^{8}–3×10^{7}	Oscillating circuits
10.	Radio frequencies	10 – 10^4	3×10^{7}–3×10^{4}	Oscillating circuits
11.	Power frequencies	5×10^{6}–6×10^{4}	60 – 50	Weak radiations from A.C. circuits

PRACTICE EXERCISE

30 mins Time Yourself

(1) **U.V radiation of 6.2eV falls on an aluminium surface, K.E of fastest electron emitted is (work function = 4.2eV)**

(a)3.2×10^{-21} J (b)7×10^{-25}J

(c)9×10^{-32}J (d)3.2×10^{-19}J

(2) **A photoelectric cells converts**

(a)light energy to elastic energy (b)electric energy to light energy

(c)light energy to mechanical energy (d)light energy to electric energy

(3) **The frequency of light beam A is twice that of light beam B. The ratio E_A/E_B of photon energies is**

(a)1 (b)4

(c)1/2 (d)2

(4) **An observer shoots parallel to a meter stick at very high (relativistic) speed and finds that the length of meter stick is**

(a)greater than one meter (b)less than one meter

(c)one meter (d) Zero

(5) **The speed of photon :**

(a) may be greater than speed of light (b) must be equal to speed of light

(c) may be less than speed of light (d) must be less than speed of light

(6) **Which one of the following radiations has the strongest photon?**

(a)T.V waves (b)micro waves

(c)X-rays (d)γ-rays

(7) **In a photoelectric e□ect experiment the stopping potential is:**

(a) the electric potential that causes the electron current to vanish

(b) the photon energy

(c) the kinetic energy of the most energetic electron ejected

(d) the energy required to remove an electron from the sample

(8) **Linear momentum of a photon is**

(a) zero (b) hf/c^2

(c) hf/c (d) c^2/hf

(9) **A device based on photoelectric effect is called**

(a) photo sensitive detection (b) photo cell

(c) photosynthesis (d) photo diode

(10) **As the intensity of incident light increases**

(a) photoelectric current increases (b) photo electric current decreases

(c) K.E of emitted photo electrons decreases (d) K.E of emitted photo electrons increases

(11) **Stopping potential for a metal surface in case of photoelectric emission depends on ______________**

(a)the threshold frequency for the metal surface

(b)the intensity of incident light

(c)the frequency of incident light and work function of the metal surface

(d)all of the above

(12) **Select an alternative form of uncertainly principle from the following_____**

(a) $\Delta\lambda \approx \frac{h}{m_o c}(1-\cos\phi)$ (b) $\Delta E \,.\, \Delta t \approx h$

(c) $mc^2 = h\nu$ (d) any of above

(13) **The slope of frequency of incident light and stopping potential for a given surface will be**

(a) h (b) hc

(c) e/h (d) h/e

(14) **If a material object moves with speed of light, its mass becomes**

(a) equal to its rest mass (b) double of its rest mass

(c) infinite (d) zero

(15) **As the temperature of black body is raised, the wavelength corresponding to maximum intensity**

(a) shifts towards longer wavelength

(b) shifts towards shorter wavelength

(c) remain the same

(d) shifts towards longer as well as shorter wavelengths

(16) **Rest mass of a photon is**

(a) infinite (b) zero

(c) very small (d) 1.67×10^{-27} kg

(17) **The name of the photon for quantum of light was proposed by**

(a) Ampere (b) Plank

(c) Thomson (d) Einstein

(18) **Einstein's photoelectric equation is given by ___________**

(a) $1/2\, mv_{max}^2 = hf + \phi$ (b) $1/2\, mv_{max}^2 - hf = \phi$

(c) $1/2\, mv_{max}^2 = hf - \phi$ (d) all of above are incorrect

(19) **In Compton scattering, the change in wave length is max. if______**

(a) angle of scattering is 90° (b) angle of scattering is 60°

(c) angle of scattering is 180° (d) angle of scattering is zero

(20) **Davison Germer experiment indicates_________**

(a) interference (b) polarization

(c) electron diffraction (d) refraction

(21) **A photon is ____________**

(a) a unit of energy (b) a positively charged particle

(c) a quantum of electromagnetic radiation (d) a unit of wavelength

(22) **Planck's work was connected with**

(a) wave nature of matter (b) photoelectric effect

(c) structure of atom (d) quantum nature of radiation

(23) **If the wavelength of incident radiation in a photoelectric experiment is decreased then**

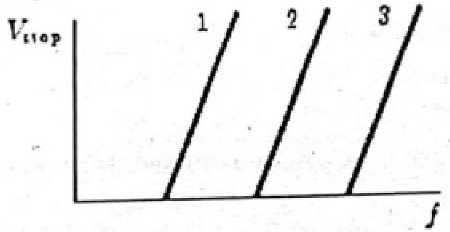
(a) the photoelectric current will decrease (b) the photoelectric current will increase

(c) the stopping potential will decrease (d) the stopping potential will increase.

(24) In a photoelectric e□ect experiment at a frequency above cut o□, the number of electrons ejected is proportional to

(a) the frequency of the incident light (b) their potential energy
(c) the number of photons that hit the sample (d) their kinetic energy

(25) The diagram shows the graphs of the stopping potential as a function of the frequency of the incident light for photoelectric experiments performed on three di□erent materials. Rank the materials according to the values of their work functions, from least to greatest



(a) 1, 2, 3 (b) 2, 1, 3
(c) 1, 3, 2 (d) 3, 2, 1

(26) According to special theory of relativity, time is not absolute quantity. This result applies to __________ timing processes

(a) physical (b) chemical
(c) biological (d) all

(27) In Compton scattering from stationary electrons the largest change in wavelength occurs when the photon is scattered through

(a) 90^0 (b) 180^0
(c) 45^0 (d) 0^0

(28) If n number of photon are striking on a metal surface, then total momentum exerted is __________

(a) nh/λ (b) $2nh\lambda$
(c) Zero (d) n fxt

(29) Which of the following is NOT evidence for the wave nature of matter?

(a) The diffraction pattern obtained when electrons pass through a slit
(b) Interference of light
(c) The photoelectric elect.
(d) The validity of the Heisenberg uncertainty principle.

(30) The velocity of a particle of mass m of de-Broglie wavelength λ is _______

(a) $\frac{2h}{m\lambda}$ (b) $\frac{m\lambda c^2}{h}$
(c) $2m\lambda c^2$ (d) $h/m\lambda$

(31) In Davisson-Germer experiment, the diffracted electron beam from crystal shows

(a) Particle property. (b) Wave property.
(c) Light property. (d) Quantum property.

(32) If a diffraction grating is placed in the path of a light beam, it reveals____

(a) Wave property. (b) Particle property.
(c) Energy particle. (d) Electromagnetic wave property.

(33) In electron microscope, we use energetic particles because of

(a) Penetrating power is high. (b) Kinetic energy is large.
(c) Wavelength is very short. (d) All the above reasons.

(34) **The resolution of 50 KV electron microscope is**

(a) 0.2 to 0.5 μm (b) 0.5 μm to 1 nm

(c) 0.5 to 1 μm (b) 0.2 nm

(35) **A three dimensional image is obtained by ____________**

(a) Electron microscope. (b) Scanning electron microscope.

(c) Magnetic imaging. (d) None of the above.

(36) **Which of the following is not a form of uncertainty principles**

(a) $\Delta x \Delta P = h$ (b) $\Delta E \Delta t = h$

(c)$m\Delta x\Delta v = h$ (d) none

(37) **Of the following which is the best evidence for the wave nature of matter?**

(a) The relationship between momentum and energy for an electron.

(b) The reflection of electrons by crystals

(c) The spectral radiancy of cavity radiation

(d) The Compton effect

(38) **The energy radiated per second per unit area of black body is directly proportional to fourth power of Kelvin's temperature is____________**

(a) Karl-wein's law. (b) Rayleigh Jeans law.

(c) Stephens law. (d) Planck's Law

(39) **Compton effect proves the ____________**

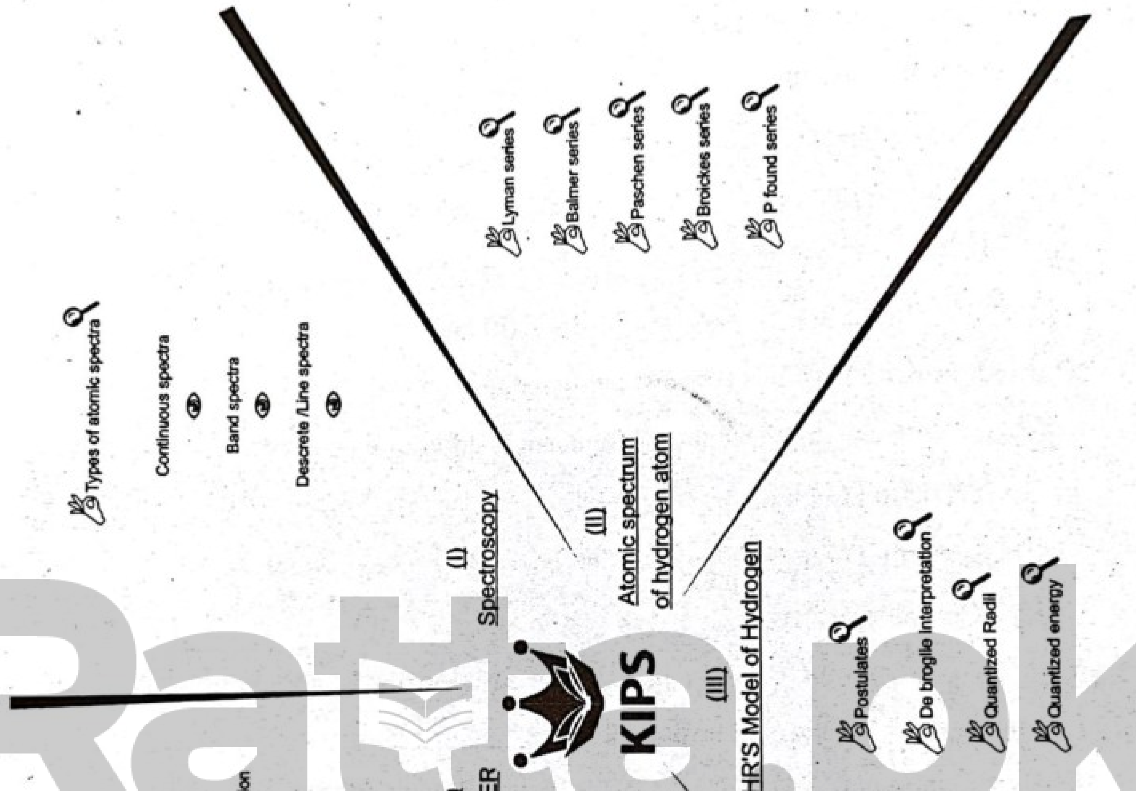
(a) Photon theory of light. (b) Dual nature of light.

(c) Wave nature of light. (d) Uncertain nature of light.

(40) **An electron is at rest. Its wavelength is**

(a) 1 (b) it has not wave character

(c) hc/m_e (d) hcm_0


KIPS
(I) Spectroscopy
Types of atomic spectra
Continuous spectra
Band spectra
Descrete /Line spectra
(II) Atomic spectrum of hydrogen atom
Lyman series
Balmer series
Paschen series
Broickes series
P found series
(III) BOHR'S Model of Hydrogen
Postulates
De broglie interpretation
Quantized Radii
Quantized energy
(IV) X – rays
Inter shell transition
Production of x – rays
Continuous X – ray spectrum
Properties and uses of X – rays
CAT scanner
(V) LASER
Normal population
Uses of Laser
Spontaneous emission
Stimulated emission
Laser Action
Population Inversion
Helium – Neon Laser

Chapter-20

SPECTRUM

Spectrum means set of frequencies absorbed or emitted by a substance.

Types

(i) **Emission Spectrum:** set of frequencies emitted by atoms of a substance.

(ii) **Absorption spectrum:** set of frequencies absorbed by atoms of a substance.

- Absorption spectrum is caused by up **transition** of atomic electrons.
- Each element has characteristic emission spectra in its vapour state.
- Emission spectra fall into following three categories: -

(i) **Continuous spectra:** It is emitted from condensed matter (solid or liquid). A **black body** spectrum is **continuous spectra**.

(ii) **Line spectra:** It is emitted by a gas or vapour state of element.

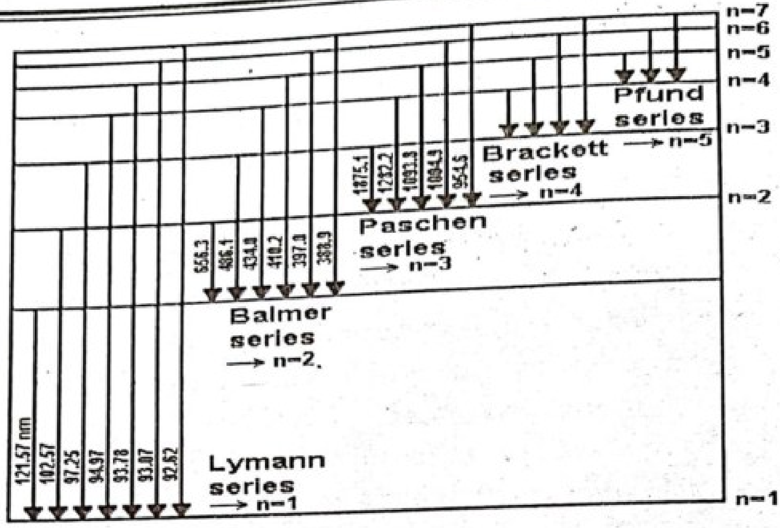
(iii) **Band spectra:** Molecular spectra is **band spectra**

SPECTRUM OF HYDROGEN

mission spectrum of H-atom consists of five series or 5 sets of spectral lines.

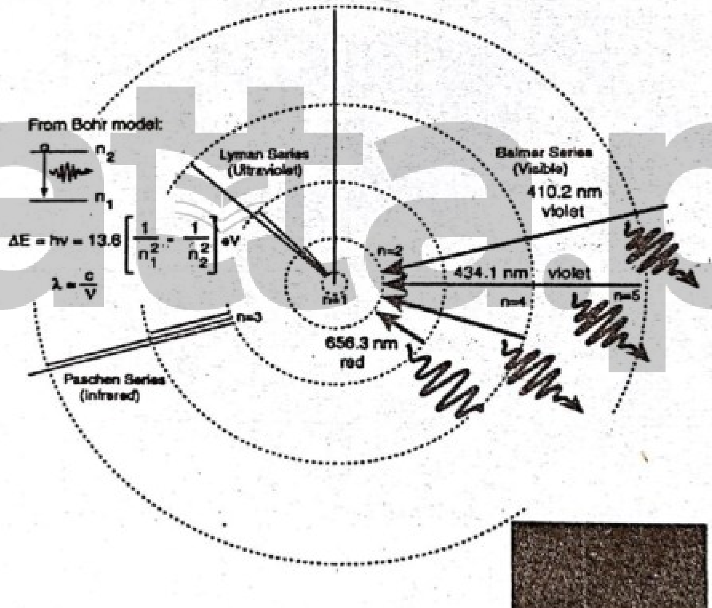
SERIES	RELATIONS	REGION	LONGEST WAVELENGTH	SHORTEST WAVELENGT
LYMAN SERIES	$\frac{1}{\lambda}=R\left(\frac{1}{1^2}-\frac{1}{n^2}\right)$ $n=2,3,4.......\infty$	U–V	Put n=2 $\lambda=\left(\frac{4}{3R}\right)=1216Å$	Put $n=\infty$ $\lambda=\frac{1}{R}=912Å$
BALMER SERIES	$\frac{1}{\lambda}=R\left(\frac{1}{2^2}-\frac{1}{n^2}\right)$ $n=3,4,5....\infty$	Visible	Put n=3 $\lambda=\frac{36}{5R}=6563Å$	Put $n=\infty$ $\lambda=\frac{4}{R}=3648Å$
PASCHEN SERIES	$\frac{1}{\lambda}=R\left(\frac{1}{3^2}-\frac{1}{n^2}\right)$ $n=4,5,6....\infty$	Infrared	Put n = 4 $\lambda=\frac{144}{7R}=18761.1Å$	Put $n=\infty$ $\lambda=\frac{9}{R}=8208Å$
BRACKET SERIES	$\frac{1}{\lambda}=R\left(\frac{1}{4^2}-\frac{1}{n^2}\right)$ $n=5,6,7....\infty$	Infrared	Put n = 5 $\lambda=\frac{400}{9R}=40533.3Å$	Put $n=\infty$ $\lambda=\frac{16}{R}=14592Å$
PFUND SERIES	$\frac{1}{\lambda}=R\left(\frac{1}{5^2}-\frac{1}{n^2}\right)$ $n=6,7,8....\infty$	Infrared	Put n = 6 $\lambda=\frac{900}{11R}=74618.18Å$	Put $n=\infty$ $\lambda=\frac{25}{R}=22800Å$

- All one-electron atoms have atomic spectra like hydrogen atom.
- Spectral lines get closer with increase in value of n until they merge at n = α called *series limit.*



BOHR'S MODEL

- Bohr, in 1913, proposed his atomic model, to remove **objections** against Rutherford atomic model.
- Bohr's atomic model is a mixture of classical and modern physics.
- Both laws of classical mechanics and quantum mechanics are applicable to atomic system.



Main points of Bohr's atomic model

(i) An electron can revolves only in those orbits in which their angular momentum is **integral multiple of** $\frac{h}{2\pi}$.

$$mv_nr_n = \frac{nh}{2\pi}$$

(ii) As long as electron remains in an allowed orbit, its energy remains constant, in spite of fact that continuously it undergoes angular acceleration.

(iii) Emission or absorption of energy from atom takes place only when its electron undergoes down or up transition between two allowed orbits.

$\Delta E = E_n - E_p$
$hf = E_n - E_p$

- Bohr's atomic model produced good results for H-atom and for one- electron atom.
- *It can't explain* ***fine structure*** *and* ***hyperfine structure of spectrum***.

BOHR'S CALCULATIONS

- ***Radius*** *of nth orbit* of the atom is given as;

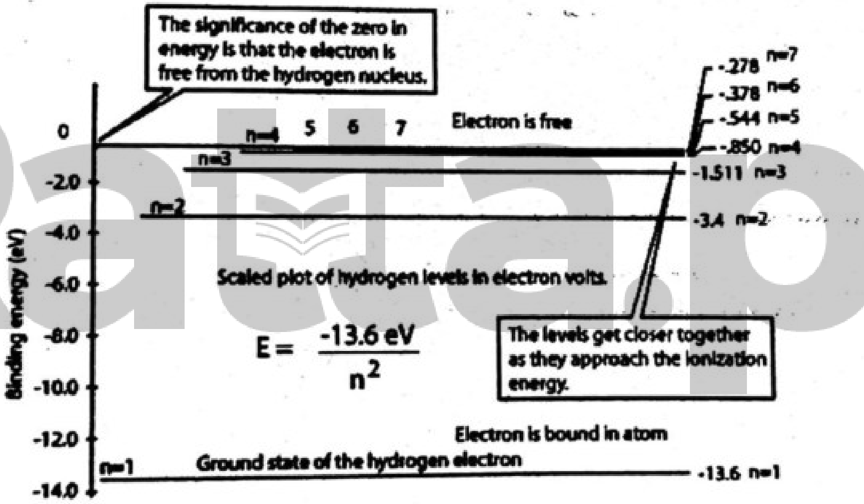
$$r_n = \frac{n^2h^2}{4\pi^2 me^2k}$$

$r_n = r_o n^2$

Where $$r_o = \frac{h^2}{4\pi^2 m e^2 k}$$

If n=1 then r_1=0.53 A°(Bohr's Radius)
Similarly,
$r_2 = 4r_1$ and $r_3 = 9\,r_1$ and so on.
It shows that radii are **quantized** and they occur in the following ratio:
$r_1:r_2:r_3$:------ = 1:4:9 -----

- The basic structure of the hydrogen energy levels can be calculated from the Schrodinger equation. The energy levels agree with the earlier Bohr model, and agree with experiment within a small fraction of an electron volt.



- **Energy** of electron in an orbit is the sum of K.E and electrical P.E.

En = KE+PE

$$K.E = \frac{ke^2}{2r_n}$$

$$P.E = \frac{-ke^2}{r_n}$$

$$En = \frac{-ke^2}{2r_n}$$

- *Energy of electron* in nth orbit is given as;

$$E_n = \frac{E_o}{n^2}$$

Where $E_o = \frac{2\pi^2 e^4 mk^2}{h^2} = 13.6eV$

$E_1 = -13.6eV$ for $n = 1$
$E_2 = -3.4$ eV for $n = 2$
$E_3 = -1.51$ eV and so on. for $n = 3$

- Graph of equation $E_n = -E_o/n^2$ is called ***energy level diagram.***
- Formula for the wavelength of nth orbit is given as;

$$\frac{1}{\lambda_n} = R_H\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

Where $n > p$
R_H = Rydberg's constant $= 1.0974 \times 10^7\ m^{-1}$.

De-BROGLIE'S INTERPRETATION OF BOHR'S ORBIT

- Third postulate of Bohr's atomic model is deduced from Plank's thesis.
- Second postulate is justified by de-Broglie
  - ✦ Electrons move in orbits in the shape of standing waves
  - ✦ Orbital velocity of electron in innermost orbit is **2.19×10^6m/sec,**

ENERGIES & POTENTIALS

Excitation potential: The potential required to raise the electron from ground state to higher state. e.g. for hydrogen,
1st excitation potential = 10.2 eV
2nd excitation potential= 12.1eV

Ionization potential: The potential required for ionization of atom e.g. for hydrogen, **13.6 V** is ionization potential.

Note:

(i) There is a large no. of excitation potentials and only limited no. of ***ionization potentials.***

(ii) Each next ionization potential is greater than its preceding one.

Excitation energy: The energy required to raise the atom from ground state to higher state.

Ionization energy: The energy required to remove electron from atom

Three ways for excitation or ionization of atom

(i) Photo ionization or excitation: photon of specified energy is incident.
(ii) Bombardment ionization or excitation: charged particle e.g. electron is incident on atom.
(iii) Thermal ionization or excitation: heat is provided.

X-RAYS

Characteristic X-Rays

- When core electron is ionized from heavy atom, then electron jumps down to occupy its place. This process is called ***inner shell transition.***
- *Inner shell transition is the origin of* **characteristics X-rays.**
- X-rays are e.m waves having wavelength 1A° to 0.5A°.
- Characteristic X-rays are emitted due to down **transition** of electron.
- A characteristic X-rays appear as discrete lines on **continuous spectrum.**
- The X-rays produced due to transitions to K- shell are called *primary X-rays.* e.g. K_α, K_β, K_γ etc.

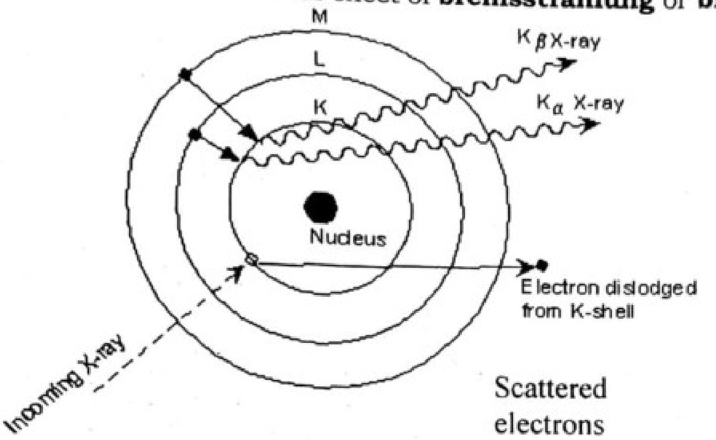
  $hf_{k\alpha} = E_L - E_K$
  $hf_{k\beta} = E_M - E_K$
  Such X-ray photons are emitted due to transition from L, M, N orbits to K-shell respectively.

Ejected Electrons

- A German physicist *Roentgen* discovered X-rays in December 1895.

Continuous X-Rays Spectrum

- The continuous spectrum is due to an effect of **bremsstrahlung** or **breaking radiation**.



Scattered electrons

- *Accelerating charge emits electromagnetic radiation.*
- *Due to deceleration of electrons in the target, X-ray radiation is emitted called* continuous background radiation or breaking radiation.
  $Ve = hf_{max}$
- Continuous background radiations are of relatively smaller wavelength.

X-RAY PRODUCTION

- Gas filled X-ray has three drawbacks:

(i) Quality can't be controlled.
(ii) Pressure decreases, so does X-rays intensity.
(iii) 98% of incident electron energy is wasted as heat and only 2% is converted in to X-rays.

- Modern X-ray unit consists of following main parts: -

Source: It is step up transformer that produces high voltage.
Target: It is a piece of heavy metal with large atomic no. like cadmium.
Filament: It is an electron source. It consists of concave shaped metal heated by **D.C operated heater** (100 mA to 500 mA).
Copper rod: It conducts out heat.
Cooling fins: It is a cooling spring in which cooling water or oil circulates.
Biological shield: It is lead case covering the whole assembly.
Window: It is a transparent window for the escape of X-rays.

- Intensity of X-rays is controlled by heater current (100 mA $\rightarrow$ 500 mA).
- Quality of X-rays is controlled by source voltage (25 KV $\rightarrow$ 100KV).

PROPERTIES OF X-RAYS

- X-rays are not affected by **electric** and **magnetic** fields.
- Frequency is greater than **ultraviolet**.
- Straight-line propagation.

X- rays exhibits:

- Reflection.
- Refraction.
- Interference.
- Diffraction (by NaCl crystal)
- Polarization.

Do you know?

The oil of higher specific heat flows in the cooling fines of x-ray production apparatus to sink the large amount of heat produced by head on collision of particles in x-ray generation

X-rays can performs

- Pass through certain opaque materials.
- Ionization.
- Photoelectric effect.
- Compton effect.
- Blackening of photographic plate.
- Damage to living cell

USES OF X-RAYS

(i) Fracture study. (Shadow Photography)
(ii) Medical diagnosis (such as **tuberculosis**).
(iii) Medical treatment (such as cancer).
(iv) Hidden things can be located (such as **weapons** and contraband things).
(v) Research field (such as X-ray diffraction for crystal structure).
(vi) Industrial uses (such as to locate **internal defects**)
(vii) Authenticity of paintings.
(viii) CAT-scanner: CAT stands for computerized axial tomography. The x-ray source produces a thin fan shaped beam that is detected on the opposite side of the subject by an array of several hundred detectors in a line. Tumors, and other anomalies much too small to be seen with older techniques can be detected.
(ix) X-rays cause damage to living tissues.
(x) X-rays are used for destruction of cancer cells
(xi) X-rays can cause cancer
(xii) X-rays can cause changes in the productive system thus damages the organism's offspring.

UNVERTAINITY WITH IN ATOM

We can prove on the basis of Heisenberg equation that electrons cannot exist in nucleus.

i.e.

If electron is in nucleus

then

$$\Delta x = 10^{-14} m$$

so using equation

$$\Delta p \geq \frac{h}{\Delta x}$$

we find

$$\Delta v = 7.3 \times 10^{10} m/sec$$

$$\Delta v > c$$

Which is not possible.

So we, can check the possibility for $\Delta x = 5 \times 10^{-11} m$ (size of atom).

Repeating the same procedure we get

$v = 1.46 \times 10^{7}$ m/sec. Which is possible?

Because **$v < c$**

*So it shows that electron is **within atom** but not in nucleus. So we can conclude that electrons can only be found in the space in between atom and nucleus called shells.*

LASER

Spontaneous and Stimulated Processes

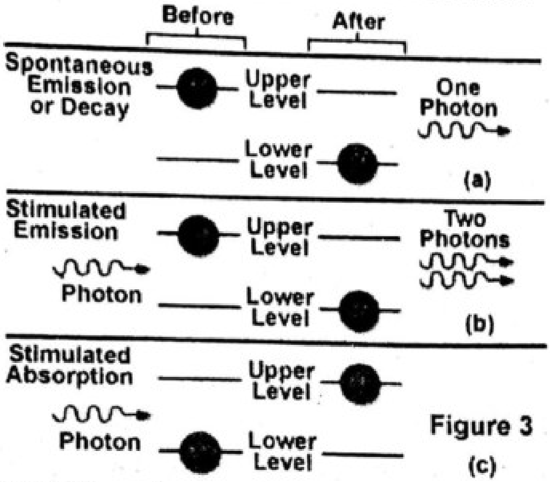


Figure 3

CHARACTERISTICS OF LASER

- Laser stands for ***light amplification by stimulated emission of radiation***.
- *Einstein developed theory of LASER* in 1917.

LASER has following characteristics: -

1- Monochromatic   2- Unidirectional   3- Coherent
4- Sharply focused   5- Highly polarized

BASIC TERMS REGARDING LASER PRODUCTION

Metastable states: It is a high energy level in which electron can stay for long time (10^{-3} sec).

Optical pumping: It is process of providing energy to initiate and maintain the process.

Population inversion: The situation in which number of excited atoms exceeds the number of atoms in ground state.

Resonance: When stimulated photon passes by excited atoms, it stimulates it to radiate photon of same energy (by going to ground state) by the principle of resonance.

Stimulated emission: In stimulated emission the incident photo induces the atom to decay by emitting a photon that travels in the direction of the incident photon.

Coherence: It means that stimulated photons have same frequency and wavelength.

Do you know?

The laser beams actually eject out from a partially mirrored surface so that the reflected photon can further carry out the stimulated emission process

LASER UNIT

Important parts of LASER unit are as follows:

(i) Cavity
(ii) Lasing material
(iii) Energy source.

TYPES OF LASER

TYPE OF LASER	EXAMPLES
Solid laser	*Ruby laser, Semi-conductor laser*
Gas laser	*He-Ne laser, CO_2 laser*
Liquid laser	*Methanol + Die laser*

PROPERTIES OF LASER

(i) Monochromatic
(ii) Coherency
(iii) Unidirectional
(iv) Reflection
(v) Refraction
(vi) Diffraction
(vii) Polarization
(viii) Affect photographic plate
(ix) May damage (high energy laser) living tissues.

APPLICATIONS OF LASER

(i) Laser as weapon (Laser-guided missiles)
(ii) Laser in industry (Drill tiny holes in steel & diamond)
(iii) Laser in research (Develop hidden finger prints)
(iv) Laser in medical treatment (Surgery of tumors, welding of retina, crush gall stones and kidney stones)
(v) It is potential energy source for inducing fusion reactions.
(vi) Laser in holography (Hologram)
(vii) Holograms are three-dimensional images.

PRACTICE EXERCISE

30 mins Time Yourself

(1) **Band spectrum is produced by**
(a)H
(b)H_2
(c)He
(d)Na

(2) **Photon of highest frequency will be absorbed when transition takes place from ______**
(a)1^{st} to 5^{th} orbit
(b)2^{nd} to 5^{th} orbit
(c)3^{rd} to 5^{th} orbit
(d)4^{th} to 5^{th} orbit

(3) **Electrons held in the atom due to** Imp
(a)weak nuclear forces
(b)gravitational forces
(c)nuclear forces
(d)coulomb's forces

(4) **If electron and proton have the same wavelength then they have same**
(a)energy
(b)velocity
(c)momentum
(d)all of above

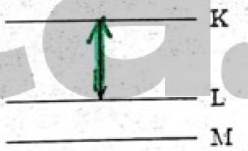
$\lambda = \frac{h}{mv}$ $\lambda = \frac{h}{P}$ const

(5) **Excited atoms return to their ground state in ______**
(a)10^{-10}s
(b)10^{-8}s
(c)10^{-6}s
(d)10^{-9}s

(6) **The most energetic photon in a continuous x-ray spectrum has an energy approximately equal to:**
(a) the energy of all the electrons in a target atom
(b) the rest energy, mc2, of an electron
(c) the kinetic energy of an incident-beam electron
(d) the kinetic energy of a K-electron in the target atom

(7) **Hydrogen atom does not emit X-rays because ______** Imp
(a)its energy levels are too close to each other
(b)its energy levels are too far apart
(c)it is too small in size
(d)it has a single electron

(8) **The transition shown gives rise to an x-ray. The correct label for this is:**



(a) K_α
(b) K_β
(c) L_α
(d) L_β

(9) **X-rays are ______**
(a)of unknown nature
(b)high energy electrons (B)
(c)high energy photons
(d)radio isotopes

(10) **In excited state the total energy is E, what is K.E with proper sign**
(a)2E
(b)E/2
(c)2/E
(d)-E Correct

K.E = $\frac{ke^2}{2r}$
T.E = $\frac{-ke^2}{2r}$

(11) **Ground state energy of the 4^{th} orbit in a H-atom is ______**
(a)–13.60 eV
(b)–3.40eV
(c)–0.85eV
(d)–1.51eV

(12) **X – Rays can not produce**
(a) Photo Electric Effect
(b) Compton's Effect
(c) Pair Production
(d) All of these

(13) **The radiations emitted from hydrogen filled discharge tube show______**
(a)band spectrum
(b) line spectrum
(c)continuous spectrum
(d) none

(14) The electric P.E of an electron in an orbit at a distance r_n from the positive charge ________

(a) Ke^2/r_n (b) Ke^2/r_n^2 $\frac{-ke^2}{Rr_n}$ $\frac{+ke^2}{r}$ →

(c) $-Ke^2/r_n$ (d) $-Ke^2/r_n^2$

(15) Radiation with wavelength longer than red lights ________

(a) ultraviolet rays (b) X-rays

(c) infra red radiation (d) visible radiation

(16) Bracket series is obtained when all transition of electron terminate on ________

(a) 4^{th} orbit (b) 5^{th} orbit

(c) 3^{rd} orbit (d) 2^{nd} orbit

(17) In an electronic transition, atom cannot emit ________

(a) γ-rays (b) infra red radiation

(c) visible light (d) ultraviolet rays

(18) Reverse process of photoelectric effect is ________.

(a) pair production (b) Compton effect

(c) annihilation of matter (d) X- rays production

(19) X rays are similar in nature to ________

(a) cathode rays (b) positive rays

(c) γ- rays (d) α- rays

(20) The penetrating power of X- rays depends on their ________

(a) applied voltage (b) Filament current

(c) source (d) all of the above

(21) A Balmer line is emitted when the electron in a hydrogen atom jumps from

(a) a higher orbit to the first orbit (b) a higher orbit to the second orbit

(c) the first orbit to a higher orbit (d) the second orbit to a higher orbit

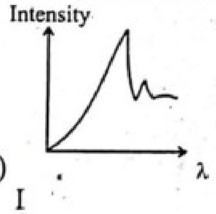
Imp

(22) A laser beam can be sharply focused because it is:

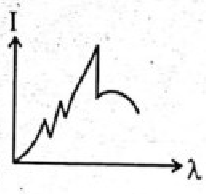
(a) circularly polarized (b) intense

(c) highly directional (d) highly coherent

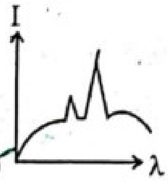
(23) Which of the following shows the best relation between wavelength and intensity?



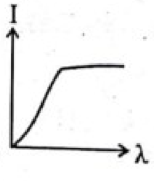
(a)



(b)



(c)



(d)

(24) Radiation emitted from TV picture tube is ________

(a) γ-rays. (b) X-rays.

(c) Far infrared. (d) Infrared.

$eV = \frac{1}{2}mv^2$ $\lambda = \frac{h}{mv}$

(25) In an X-ray tube, electrons each of charge e are accelerated through V potential difference allowed to hit a metal target. The wavelength of the X-rays emitted is ________

$\lambda = \frac{h}{mc}$ $mv = \frac{h}{\lambda}$

(a) *hc/eV* (b) *he/Vc*

(c) eV/h (d) impossible to predict

$eV = \frac{1}{2}\frac{h}{\lambda}v$

$\lambda = \frac{hv}{eV}$

(26) **The minimum wavelength of X-rays can further be reduced by_______**
(a) Reducing the pressure or cooling the target.
(b) Increasing the temperature of the filament.
(c) Using a target element of higher atomic number.
(d) Increasing the potential difference between the cathode and the target. → characteristic → continuous

(27) **The characteristic X-rays spectrum is due to ______**
(a) The illumination of the target metal by ultra-violet radiation.
(b) The bombardment of the target by protons.
(c) The bombardment of target by electrons.
(d) The absorption of γ radiation by the target metal.

(28) **LASER action can't be achieved without**
(a) population inversion
(b) induced emission
(c) laser
(d) all of them

(29) **Maximum frequency in the spectrum from X-ray tube is directly proportional to the ______**
(a) Number of incident electron i.e. filament current.
(b) The kinetic energy of the incident electron i.e. the potential difference through which they are accelerated.
(c) The soft target which can easily emit electrons.
(d) all of above are correct.

(30) **X-rays are diffracted by a crystal but not by a diffraction grating because ______**
(a) The ions in a crystal are well arranged.
(b) The lines in a diffraction grating cannot reflect X-rays.
(c) The penetration power of X-rays is high in a diffraction grating.
(d) The wavelengths of X-rays are of the same order of magnitude as the separation between atoms in a crystal.
Imp

(31) **UV radiation can be produced by**
(a) Heating the filament.
(b) Electron excitation in the gas.
(c) Ionization of atoms.
(d) All the above.

(32) **What is the velocity of a particle of mass m & de-Broglie wavelength λ?**
(a) $\frac{h}{m\lambda}$
(b) $\frac{2h}{m\lambda}$
(c) $\frac{mh}{\lambda}$
(d) $\left(\frac{2hc}{m\lambda}\right)^{\frac{1}{2}}$

(33) **Protons are accelerated form rest by a potential difference 4 kV and strike a metal target. If a proton produces one photon on impact of minimum wavelength λ_1 and similarly an electron accelerated to 4 kV strikes the target and produces a minimum wavelength λ_2 then**
(a) $\lambda_1 < \lambda_2$
(b) $\lambda_1 > \lambda_2$
(c) $\lambda_1 = \lambda_2$
(d) no such relation can be established

(34) **Electron cannot exist in the nucleus; it is confirmed by observing that**
(a) It does emit γ-radiation.
(b) Its size as compare to proton and neutron is very small.
(c) No antiparticle of electron is present.
(d) The velocity of electron must by very high according to uncertainty principle.

(35) **X-rays and γ-rays both are electromagnetic waves. Which of the following statements is correct?**

(a) The wavelength of X-rays is less than that of γ-rays

(b) The wavelength of X-rays is greater than that of γ-rays

(c) The frequency of γ-rays is less than that of X-rays.

(d) The frequency and wavelength of X-rays are more than those of γ-rays.

(36) **In laser production, the state in which more atoms are in the upper state than in the lower one is called ______**

(a) Metal stable state. (b) Normal state.

(c) Inverted population. (d) All the above.

(37) **The stay of electron in metastable state for an atom in laser light is______**

(a) 10^{-4}sec. (b) 10^{-5}sec.

(c) 10^{-3}sec. (d) 10^{-8}sec.

(38) **In He-Ne laser, the lasing action is produced by______**

(a) Ne only. (b) He-Ne both.

(c) Electrons of He. (d) Electrons of Ne.

(39) **Reflecting mirrors in laser is used to ______**

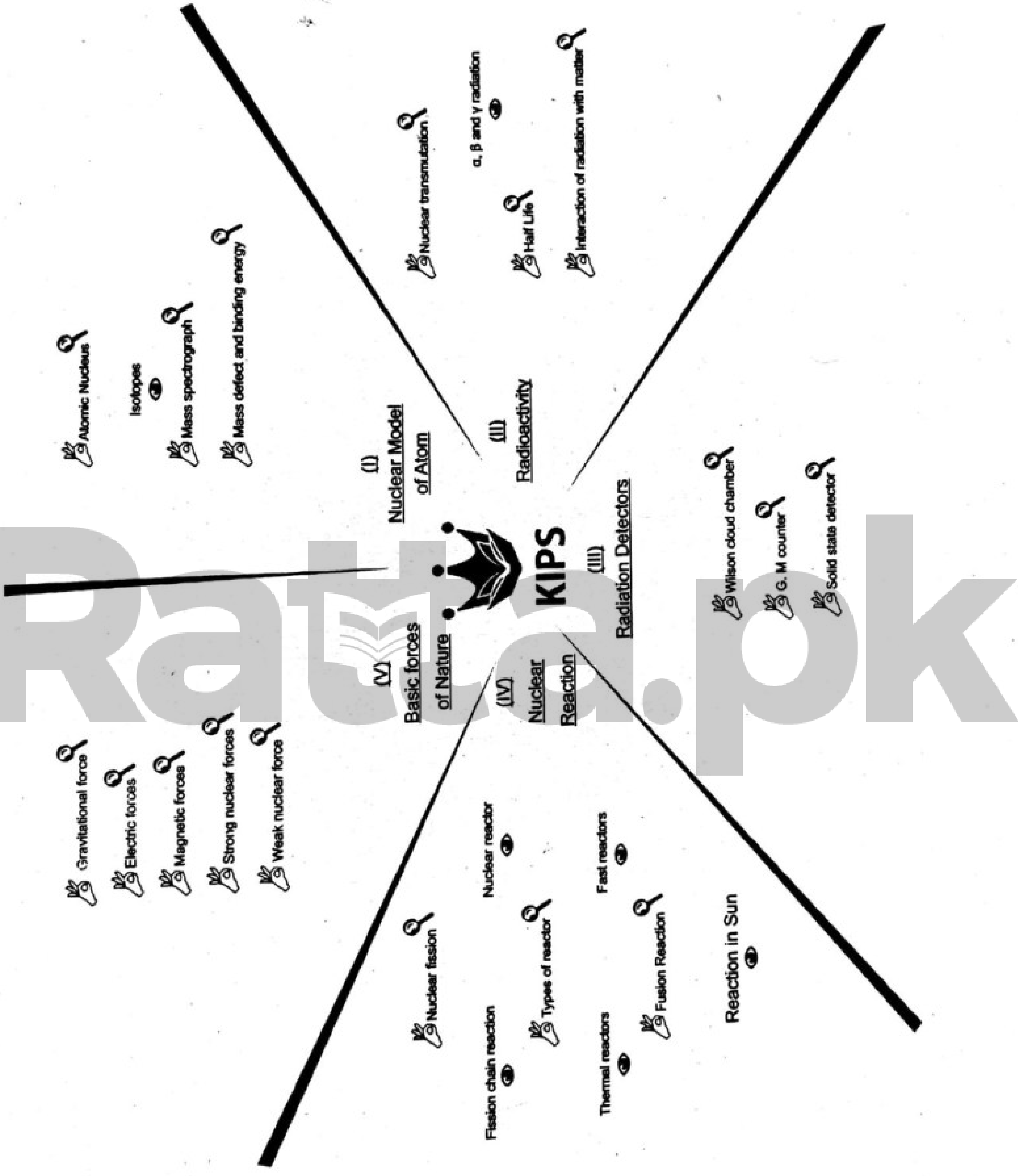
(a) Further stimulation. (b) Lasing more.

(c) For producing more energetic lasers. (d) All the above.

(40) **The velocity of laser light is ______**

(a) Less than ordinary light. (b) More than ordinary light.

(c) Equal to ordinary light. (d) Different for different colours or frequency.


KIPS
(I) Nuclear Model of Atom
Atomic Nucleus
Isotopes
Mass spectrograph
Mass defect and binding energy
(II) Radioactivity
Nuclear transmutation
α, β and γ radiation
Half Life
Interaction of radiation with matter
(III) Radiation Detectors
Wilson cloud chamber
G. M counter
Solid state detector
(IV) Nuclear Reaction
Nuclear fission
Fission chain reaction
Nuclear reactor
Types of reactor
Thermal reactors
Fast reactors
Fusion Reaction
Reaction in Sun
(V) Basic forces of Nature
Gravitational force
Electric forces
Magnetic forces
Strong nuclear forces
Weak nuclear force

J.J. THOMSON'S MODEL OF ATOM

Postulates

(i) Atom is a neutral as a whole, in which negative electrons are embedded on positive nucleus.

(ii) Density of atom is **uniform.**

(iii) There is no empty space in the atom.

Objections

(iv) There is no static equilibrium between electron and positive charge.

(v) Density of atom is **not uniform.**

RUTHERFORD'S ATOMIC MODEL

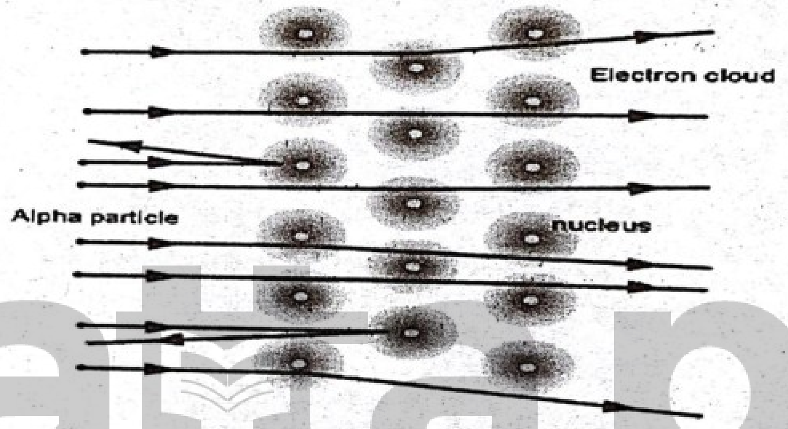
Postulates

(i) Most of the part of atom is empty.

(ii) Central part is tiny and positively charged. It is called **nucleus.**

(iii) Electrons are revolving about nucleus in **circular orbits.**

(iv) Almost whole of mass is **concentrated** in nucleus (i.e. atom has non-uniform density).



Objections

(i) The revolving electrons if moving **continuously**, will emit energy **continuously**.

(ii) If energy is emitted continuously, then spectrum should be **continuous** but a line **spectrum** is obtained.

(iii) If energy is emitted continuously, then atomic assembly will collapse

BOHR'S ATOMIC MODEL

Postulates

(i) Electron can revolve only in those orbits in which its angular momentum is integral multiple of $\frac{h}{2\pi}$

$$mvr = \frac{nh}{2\pi}$$

Such orbits are called ***allowed orbits*** *or stationary state or Bohr's orbits.*

(ii) As long as an electron remains revolving in its allowed orbit, the energy of electron remains **constant.**

(iii) When electron jumps down between two allowed orbits, it **radiates** energy in the form of photon of energy as given below.

$\Delta E = E_2 - E_1 = hf$

Objections

(i) Electronic orbits are not **circular.**

(ii) Fine structure of atomic spectra could not be explained.

(iii) Effect of nuclear motion on atomic spectra is not made **clear.**

NUCLEUS & ITS COMPOSITION

- Nucleus is a tiny region in which almost all mass of atom is **confined**.
- Rutherford thought that whether nucleus is a lump of mass or it is an **aggregate** of particles.
- Size of atom is **10^{-10}m** and that of nucleus is **10^{-14}m**.
- According to Rutherford's findings, nucleus is composed of neutron and **proton, collectively known as nucleons**, symbolized as:

$${}_{Z}X^{A}$$

Where Z = no. of electrons or protons in neutral atom = charge no.
A = sum of proton and neutron in a nucleus = mass no.

So,

No. of neutron = N = A - Z

- In small atom N=Z, while in heavy atom N>Z.

Discovery of Nucleons

(i) Proton (by Rutherford)

$${}_{2}He^{4} + {}_{7}N^{14} \rightarrow {}_{8}O^{17} + {}_{1}H^{1}$$

(ii) Neutron (by Chadwick)

$${}_{2}He^{4} + {}_{4}Be^{9} \rightarrow {}_{6}O^{12} + {}_{0}n^{1}$$

- *Hydrogen (simple hydrogen) is the only atom whose nucleus contains* ***no neutron.***
- According to modern research, the number of particle existing in nucleus is 37.
- Mass of nucleus is roughly equal to sum of masses of nucleons.
- *Unit of mass at atomic level is a.m.u.*

$$1 \text{ a.m.u} = 1.66\times10^{-27} \text{ kg}$$

- Masses of some well-known particles on a.m.u scale are given below;

Particle	*Symbol*	*Mass (in a.m.u)*
Electron	$_{-1}e^{\circ}$	***0.00055 a.m.u***
Proton	$_{1}H^{1}$	*1.007276 a.m.u*
Neutron	$_{0}n^{1}$	*1.008665 a.m.u*
Deuteron	$_{1}H^{2}$	*2.014102 a.m.u*
Helium nucleus	$_{2}H^{4}$	*4.002603 a.m.u*

For your information

We can calculate number of neutrons in a nucleus by simply subtracting mass number and atomic number i.e. ${}_{92}U^{235} \rightarrow 235-92=143$

So this nucleus contains 143 neutrons.

- **1.a.m.u = 931 MeV** $\Rightarrow$ 1.66×10^{-27} kg = 931 MeV

Isotopes

"Isotopes are such nuclei of an element having the same atomic number but different mass number."

- Isotopes have same number of protons.
- They have different number of neutrons.
- Isotopes of an element have the same **chemical** but different **physical** properties.

MASS SPECTROGRAPH

Mass spectrograph is an electromagnetic instrument used for the measurement of ***masses*** *of isotopes.*

Principle of mass spectrograph

$r \propto \sqrt{m}$

- *Radius of path* described by charged ion in mass-spectrometer is given as;

$$r = \sqrt{\frac{2Vm}{B^2e}}$$

Where V = potential difference
e = charge
B = magnetic field

- Mass spectrograph sorts out positive ions
- Centripetal forces of the magnetic field provide the isotopes a suitable radius to bend about.

NUCLEAR FORCES

- Nucleus contains protons that repel each other, may cause the destruction of **nucleus**.
- There are two *classical forces*, operating in nucleus.

(i) Coulomb's repulsive force;

$$F_e = \frac{K e^2}{r^2}$$

(ii) Newton's attraction force;

$$F_g = \frac{Gm^2}{r^2}$$

- Classical forces are unable to give stability to the nucleus because;
- Due to strong repulsive forces in nucleus, it requires much energy for the entry of another charged particles e.g. proton.

Example: 7.2 MeV energy is required to the addition of 1 proton into a nucleus of 50 **protons**

- Force, which has binding effect on nucleons to give stability of nucleus, is called ***strong nuclear force.***

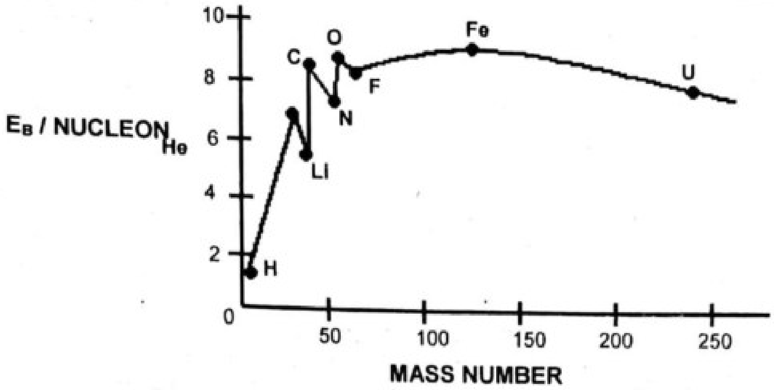
Properties of strong nuclear force

(i) It does not obey inverse square law.
(ii) It is the strongest force having range equal to nuclear diameter 10^{-14}m.
(iii) It is always attractive force and has binding effect inside the nucleus.
(iv) Strong nuclear force is attractive only within nucleus while a strong force of repulsion is outside the nucleus because of coulomb's **repulsive force.**

MASS DEFECT

Mass defect is the difference between mass of **nucleus** and sum of **masses** of its **nucleons.**
Δm = sum of masses of nucleons – mass of nucleus
e.g. for deuterium ($_1H^2$), $\Delta m = 0.002388$ a.m.u

- Mass defect Δm is converted into energy Δmc^2 called ***binding energy.*** It is liberated in the form of photon.
  $E = \Delta m \times 931\text{MeV} = [(Z\,m_p - N\,m_n) - m] \times 931\text{MeV}$
- After liberation of binding energy ($E = \Delta\, mc^2$), the nucleus becomes stable e.g. B.E for deuterium is **2.24 MeV.**
- When energy equal to binding energy is provided to nucleus, somehow, the nucleus dissociates into nucleons.
- Binding energy can be given as energy required to dissociate nucleus into **nucleons.**
- Graph between mass number (A) and B.E per nucleon is shown below:



- Following conclusions can be drawn from above curve:

(i) Binding energy of a light atom is very large, that is why they are stable (maximum value is at A=56).

(ii) Binding energy per nucleon for heavy atoms is smaller, that is why they are less stable.

(iii) Binding energy (B.E) increases with increasing A. B.E decreases with increase in A if Z > 82.

(iv) The binding energy per nucleon is maximum for iron.

- $\Delta m/A$ is called ***packing fraction***

RADIOACTIVITY

- Becquerel discovered **radioactivity**.
- Nuclei having Z > 82 are unstable and they emit α, β and γ rays; the phenomenon is called ***radioactivity.***
- Some radioactive elements are Po (Z=84) Rd (Z=88) and U (Z=92) etc.

α-decay

Charge no. (Z) decreases by 2 and mass no. (A) by 4

$$_{Z}X^{A} \longrightarrow {}_{Z-2}Y^{A-4} +_{Z} He^{4} + Q$$

e.g.

$$_{92}U^{238} \longrightarrow {}_{90}Th^{234} +_{2} He^{4} + 4.3\text{Mev}.$$

β-particle

- β-particle is electron or positron coming from nucleus. So it may be classified as;

(i) β^- decay

$$_{Z}X^{A} \longrightarrow {}_{Z+1}Y^{A} + {}_{-1}\beta^{\circ} + \upsilon +$$

Only charge no. (Z) **increases by 1.**

Its prototype is decay of neutron itself that changes to p and $_{-1}e^{\circ}$.

$$^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}_{-1}\beta^{\circ} + \bar{\upsilon}$$

e.g.

$$_{11}Na^{24} \longrightarrow {}_{12}Mg^{24} + {}_{-1}\beta^{\circ} + \bar{\upsilon}$$

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(ii) β^+-decay

$$_{Z}X^{A} \longrightarrow {}_{Z-1}X^{A} + {}_{+1}\beta^{o} + \bar{\upsilon}$$

Only charge no. (Z) **decreases by 1.**
Its prototype is decay of proton itself that changes to n and $_{+1}e^{o}$.

$$^{1}_{1}p \longrightarrow {}^{1}_{0}n + {}_{+1}\beta^{o} + \upsilon$$

e.g.

$$_{9}F^{17} \longrightarrow {}_{8}O^{17} + {}_{+}\beta^{o} + \upsilon$$

NOTE: *Weak interaction only appears in β-decay.*

γ-decay

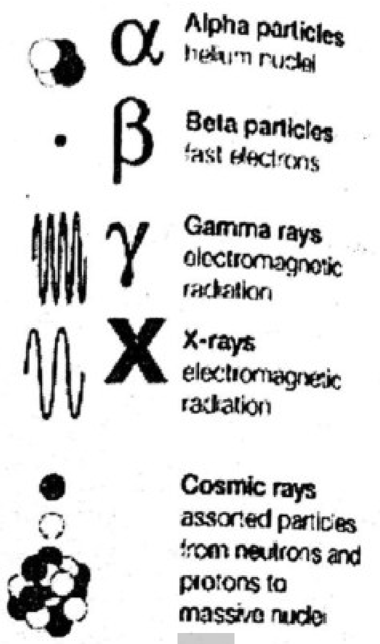
γ-decay is due to de-excitation of nucleus.

e.g. $zX^{A} \longrightarrow zX^{A} + \gamma$, * show **excitation of** atom

$$_{38}{}^{*}Sr^{87} \longrightarrow {}_{38}Sr^{87} + \gamma \text{ - photon}$$

$$_{12}Mg^{27} \longrightarrow {}_{13}{}^{*}Al^{27} + {}_{-1}\beta^{o} + V$$

$$_{13}{}^{*}Al^{27} \longrightarrow {}_{13}Al^{27} + \gamma\text{-photon}$$



Type of Radiation	Alpha particle	Beta particle	Gamma ray
Symbol	α or $^{4}_{2}\alpha$ or $^{4}_{2}He$	$_{-1}\beta^{o}$ or $_{+1}\beta^{o}$	γ (can look different, depends on the font)
Mass *(atomic mass units)*	4	1/2000	0
Charge	+2	-1 or +1	0
Speed	slow	fast	very fast (speed of light)
Ionizing ability	high	medium	0
Penetrating power	low	medium	high
Stopped by:	paper	aluminium	lead

HALF-LIFE OF ELEMENTS

- Radioactive decay is a random process so we get idea of **half-life**.
- The half-life $T_{1/2}$ of a radioactive element is that period in which half of the atoms decay.
- Half-life ($T_{1/2}$) depends on element and is not affected by any physical change or chemical change.
- Half-life may be classified as follows:

(i) **Extremely short half-life:** $T_{1/2}$ in micro or nano seconds
(ii) **Moderate half-life:** $T_{1/2}$ in minutes.
(iii) **long half-life:** $T_{1/2}$ in years.

- Half- life can be given as: $\mathbf{T_{1/2} = 0.693/\lambda}$
  Wher[illegible] called ***decay constant*** depends upon nature of material. Decay constant of any [illegible] is equal to the fraction of the decaying atoms per unit time. The unit of the decay constant is s^{-1}.
- The decay curve shows that radioactive element decay exponentially
- *Half-life is used to identify an atom.*

LAWS OF RADIOACTIVITY

- $\Delta N/\Delta t \propto N_o$
- $\Delta N/\Delta t = -\lambda N_o$
- $N_t = e^{-\lambda t}N_o$
- $T_{1/2} \propto 1/\lambda$
- $\lambda = \dfrac{\Delta N/\Delta t}{N}$
- Mean life $= T = 1/\lambda$

INTERACTION OF RADIATION WITH MATTER

α, β & γ rays are called nuclear radiations.

- Interaction of nuclear radiations with matter depends on three characteristics of nuclear radiations.

(i) Mass of particle
(ii) Charge of particle
(iii) Energy of particle
(iv) Density of the medium
(v) Ionization potentials of the atoms of the medium

INTERACTION OF α-RAYS

- α-particle can do ionization in following two ways.

(i) Mechanical collision (α- particle directly hits electron)
(ii) Coulomb's interaction (electrostatic interaction)

- Mode of ionization by Coulomb's interaction (electrostatic attraction) for α-rays dominates over that by direct collision.
- *The path of ionization followed by α-rays is straight and continuous* because of its high **ionization power and large mass.**
- During ionization, α-particle continuously looses its energy as a result of which its velocity decreases.
- 7.7 MeV α-particle produces 2×10^5 ion pairs before stopping in average.
- When α-particle has spent all its energy on ionization, it absorbs two electrons from its surroundings gas and becomes a neutral (He atom).
- Range of α-particle in air is small due to intense ionization.
- 7.7 MeV α-particle has 7cm range in air at S.T.P, which reduces further in denser medium.
- Range of 7.7MeV α-particle in aluminum is only 0.04 mm.
- α-particle produces disintegration in nuclei of some atoms if they have high energy.

INTERACTION OF β-RAYS

- β-particles are fast electrons or positrons coming from nucleus.
- Range of β-particle is larger than that of α-particle by a factor of 100.
- Ionization of β-particle is smaller than that of α. (100 times less)
- Mass of β-particle is equal to that of an electron.
- Charge of β-particle is equal to 1.6×10^{-19}C that may be positive for positron ($_{+1}\beta^{0}$) and negative for electron ($_{-1}\beta^{0}$).
- β-particle does ionization due to electrostatic repulsion (in case of $_{-1}\beta^{0}$) and attraction (in case of β^{+}).
- Ionization path of β is broken and **zigzag due to its** smaller mass.
- Ionization by head-on-collision is very rare.
- β-particle looses almost all its energy in a single encounter.

- Because of lesser ionization encounters, penetration of β is 100 times larger than that of α-particle of same energy.
- 3 MeV β-particle can pass through 6.5mm aluminum foil.
- β-particle can produce fluorescence.

INTERACTION OF γ-RAYS

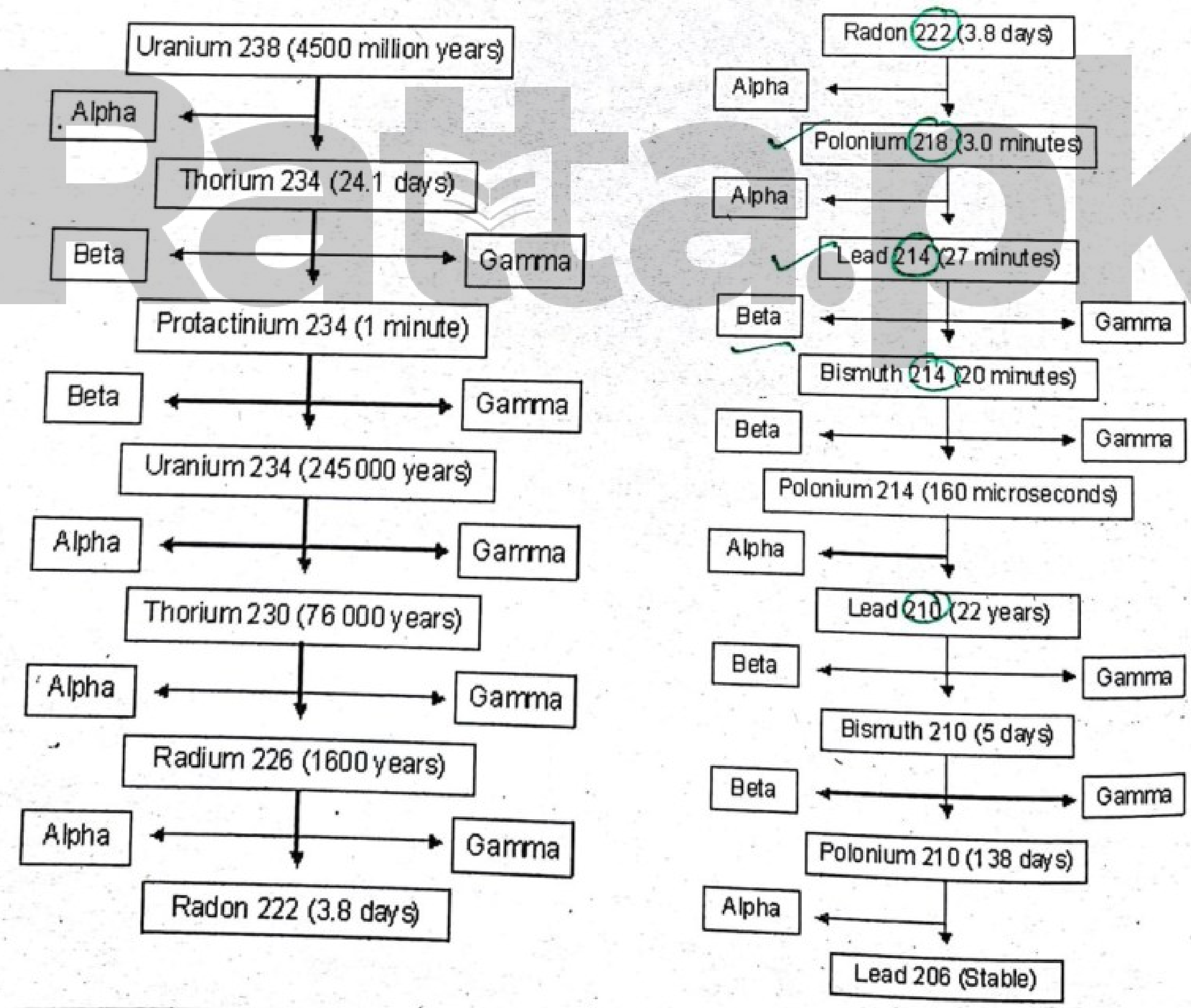
- γ-rays being photons can't be stopped by matter (lead can be used as a shield because of its high electron density).
- γ-rays have shorter wavelength than X-rays.
- γ-particles loose their energy by following three ways.

(i) Compton effect
(ii) Photoelectric effect
(iii) Pair production.

- The type of interaction depends upon energy range of photon available according to following scheme:

ENERGY RANGE	TYPE OF INTERACTION
$E < 0.1$ MeV	Photoelectric effect
$E = 0.1$Mev to 1MeV	Compton effect
$E > 1.02$ MeV	Pair production

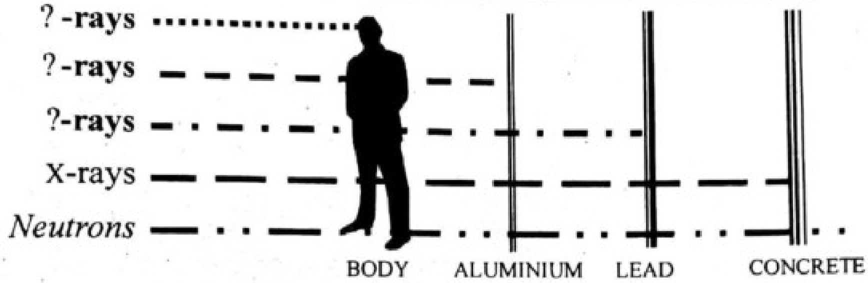
Element Made from Nuclear Reaction of Uranium



INTERACTION OF NEUTRONS

- Neutrons are more effective radiation than both α and β rays because they bear no charge as **regard to penetration**.
- When neutron is captured by a nucleus, it results in the formation of a **radioisotope**.
- Neutron causes fission in heavy nuclei.
- Neutron can knock down electrons out of body cells causing **instantaneous death**.

COMPARISON OF PENETRATION POWER OF VARIOUS RADIATIONS



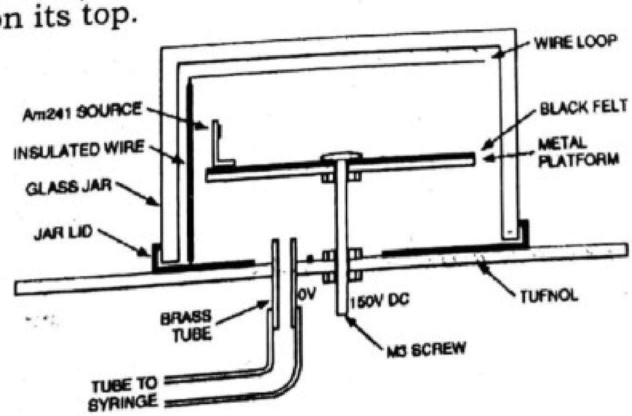
Radiation	Description	Penetration	Ionization	Effect of E or B field
Alpha (α)	Helium nucleus 2p + 2n Q = + 2 *e*	Few cm in air or in Thin paper	Intense, about 10^4 ion pairs per mm.	Slight deflection as a positive charge
Beta (β)	High speed electron Q = -1 *e*	Few mm in aluminium	Less intense than a, about 10^2 ion pairs per mm.	Strong deflection in opposite direction to E.
Gamma (γ)	Very short wavelength Em radiation	Several cm in lead, couple of m in concrete	Weak interaction about 1 ion pair per mm.	No effect

WILSON CLOUD CHAMBER

- C.T.R Wilson in 1911 invented Wilson cloud chamber.
- Wilson cloud chamber is based upon the following principle: - "Super saturated droplets prefer to condense on ions or dust particles similar to formation of clouds."

Construction

It consists of a circular base metal plate with hole in the center. Above it, is another metal plate with a black felt pad. A Perspex or glass dome fits over the two plates with the source on its top.

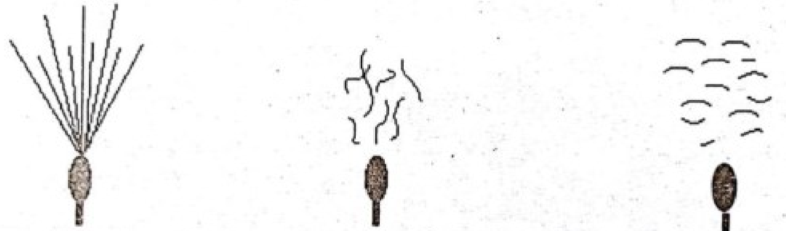


Procedure

Due to adiabatic expansion, the super-saturated droplets are produced. When nuclear radiation enters, it produces ionization and water vapours condense on such ions. They reflect light to make the path of ionizing particles visible. A high-speed camera photographs the track of ionizing particle.

Track of Ionizing Particle

Name of Particle	*Shape of Track*
α-particle	*Solid and continuous*
β-particle	*Zigzag and discontinuous*
γ-particle	*No definite track*



α-rays β-rays γ-rays

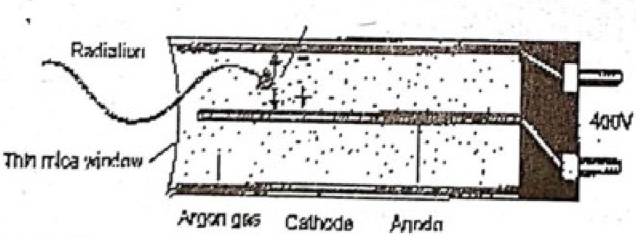
- By applying magnetic field, the α & β particles deviate from its original path.
- By measuring radii of curvature, we can also measure e/m ratio of α & β particles.
- Length of cloud tracks is proportional to energy

GEIGER - MULLER COUNTER

- Geiger and Muller invented G.M counter (Geiger - Muller counter).

Construction

G.M counter consists of a metal tube (cathode) containing inert gas (such as argon & alcohol or bromine and neon) at 0.1 atmospheric pressure. There is a thin wire (anode) co-axial with metallic tube.



The Geiger Mueller counter is an electronic instrument used for detecting and measuring low level $\beta-$particle and $\gamma-$ray radiation. It cannot detect $\alpha-$particles. It is also known as a G-M Counter.

Procedure

(i) When nuclear radiation enters, it produces ionization in halogen gas ions.

(ii) **Positive ions move** towards negative metallic plate while negative ions **towards positive** wire.

(iii) Electrons released by nuclear radiation rush towards the positive wire knocking out electrons from atoms of gas in their way. In this way an **avalanche** of electrons reach the wire and hence current pulse is produced.

(iv) The current pulse is detected across a **resistance of $10^9\,\Omega$**.

Quenching of Discharge

Positive ions on reaching the metal tube pull out electrons. These electrons can excite the atoms, which on returning to ground state emit photons, which then

ejects **photoelectrons under photoelectric effect**. To avoid photoelectrons, we do quenching.

Quenching of discharge in G.M counter is attained by following two ways:

(i) Manual quenching: by lowering voltage below critical value of discharge.

(ii) Self-quenching: by adding bromine gas into principal gas (neon). The mechanism is such that the I:E of bromine is lower than neon, the ions of quenching gas reach the cathode before principal gas ions. When they reach near the cathode, they capture electron and become neutral molecules. Following neutralization, the excess energy of the quenching molecules is dissipated in dissociation of the molecules rather than in the release of electrons from the cathode.

- G.M counter can be used to study β and γ-rays effectively.

SOLID STATE DETECTOR

- Solid State detector is most sensitive **detector capable of detecting** three α, β & γ-rays.

Construction

Solid State detector mainly consists of reverse biased diode.

Procedure

When radiation falls on the diode, it causes the release of electrons, creating some sort of conduction path. The voltage caused due to flow of electrons is measured.

Advantages

(i) Compact size
(ii) Very fast detector
(iii) No need of quenching
(iv) Portable
(v) Can detected α, β and γ-rays.
(vi) Low energy utilization (requires 3eV — 4eV of energy

NUCLEAR FISSION

- *Otto Hahn* and his co-workers discovered nuclear fission accidentally when they were attempting to prepare transuranic elements by bombarding ${}_{92}U^{235}$ with ${}_0n^1$ (slow).
- ***Transuranic** elements* are those elements that have atomic no. greater than that of uranium (the heaviest natural element) e.g. Np (Z=93), Pu (Z=94) etc.
- There are 30 different ways by which nucleus can undergo **fission** accompanied by 2 to 5 neutrons (average is 2.5 neutrons).
- *Fission neutrons are ejected by **daughter or fission fragment**, not by parent nucleus.*
- During fission, 99 percent neutrons are ejected in extremely short time and are called prompt neutrons; the remaining 1% are emitted a litter latter. They are called ***delayed neutrons.***
- Unstable fission fragments, to become stable, eject delayed neutrons.

Isotopes of Uranium

Ore	*Percentage*	*Half-life*
${}_{92}U^{238}$	*99.38%*	*4.51 x 10^9years*
${}_{92}U^{235}$	*0.714%*	*7.1 x 10^8years*
${}_{92}U^{234}$	*0.006%*	*2.48 x 10^5years*

- For fission of ${}_{92}U^{238}$, n^1 of energy 1 MeV is required while for ${}_{92}U^{235}$, ${}_0n^1$ of energy 0.04 eV is required.
- Two common fission reactions for uranium are as follows:

$${}_0n^1 + {}_{92}U^{235} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + 200\text{ MeV (Q)}$$

$${}_0n^1 + {}_{92}U^{235} \longrightarrow {}_{54}Xe^{140} + {}_{38}Sr^{94} + 2\,{}_0n^1 + 200\text{ MeV}$$

where Q is called energy of nuclear reaction.

TYPES OF FISSION

(i) Controlled fission chain reaction.
In this reaction only one neutron, out of all the neutrons created in one fission reaction, becomes the cause of further fission reaction. It is the underlying principal of nuclear reactor.

(ii) Critical mass
Such a mass of uranium in which one neutron, out of all the neutrons produced in one fission reaction, produces further fission is called critical mass.

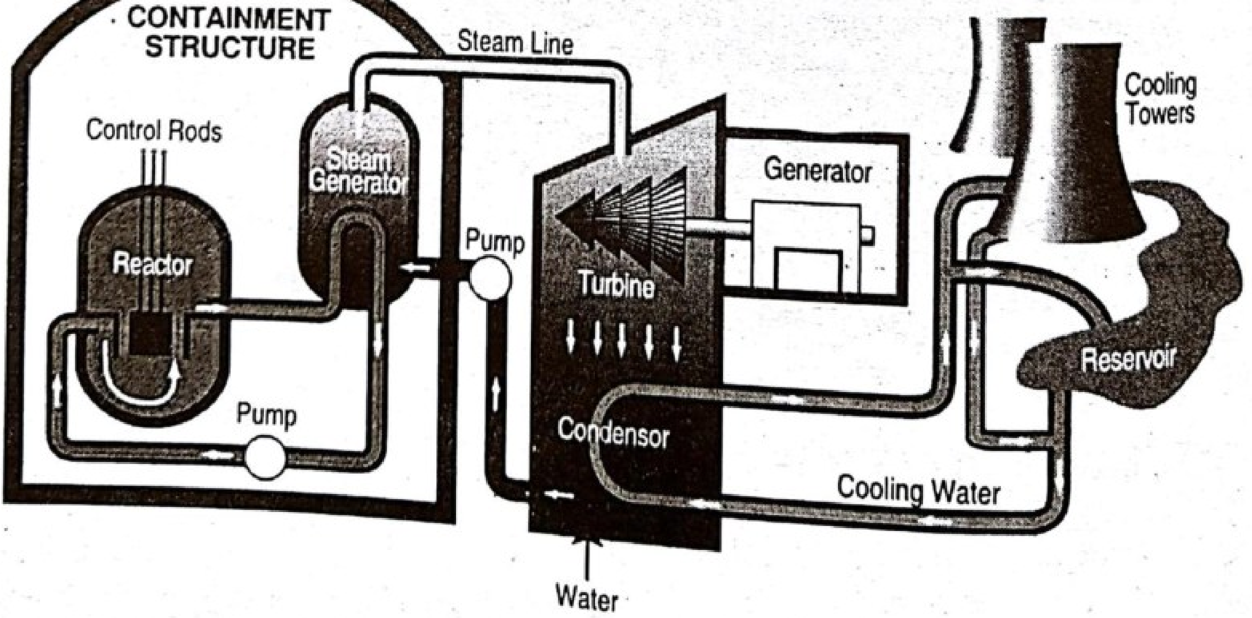
(iii) Uncontrolled fission chain reaction
If the mass of uranium is much greater than the critical mass, then the chain reaction proceeds at a rapid speed and a huge explosion is produced. Atom bomb works at this principal

- *Fermi carried out first* ***controlled fission*** *in 1942.*
- Fission of $_{92}U^{235}$ atom releases 10^8 times as much energy as is released by $_6C^{12}$ atom in ordinary furnace.
  1 kg of $_{92}U^{235}$ contains ⇒ $(1000\text{ g}/235)\times 6.023\times 10^{23} = 25.6\times 10^{23}$ atoms
  We know that,
  1 atom of $_{92}U^{235}$ gives ⇒ 200 MeV
  ∴ 1kg of $_{92}U^{235}$ gives ⇒ 5.12×10^{26} MeV
  We know that,
  Time for one fission ⇒ 10^{-8} sec
  ∴ Time for 60 fissions ⇒ 0.6μs
  Thus 5×10^{26} MeV energy is liberated in 0.6μs when 1 kg of $_{92}U^{235}$ undergoes complete fission.
- Plutonium-239 and uranium-233 are also being used as fuel.

NUCLEAR REACTOR

Fission chain reaction can be controlled in a device called **nuclear reactor.**

- Nuclear reactor works according to principle that the environment of nuclear reactor is controlled in such a way that only one slow neutron takes part in fission process at a time.



PARTS OF NUCLEAR REACTOR

(i) **Fuel rods:** $_{92}U^{235}$ is used as fuel. In this fuel the quantity of $^{235}_{92}U$ is increased from 2 to 4 percent.
(ii) **Control rods:** Ba or Cd rods absorb neutrons efficiently.
(iii) **Moderator:** to slow down neutrons usually **graphite**
(iv) **Heat exchanger:** to convey the energy produced for the sake of use.
(v) **Cooling system:** to avoid over **heating**
(vi) **Core:** consists of fuel, control rods and moderator.
(vii) **Biological shield:** to prevent scattering of **harmful radiations.**
(viii) **Breeding:** Breeder nuclear reactor is that which prepare its fuel by itself.

TYPES OF NUCLEAR REACTORS

(i) Thermal reactor
(ii) Fast reactors

Thermal Reactor

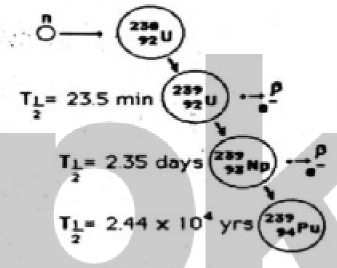
- Neutrons must be **slowed down** to thermal energies to produce fission.
- In this reactor U^{235} is used as fuel.

Fast Reactors

- Fast neutrons are used to strike $_{92}U^{238}$ producing $_{93}Np^{239}$ and then $_{94}Pu^{239}$. This type of reactor is liquid metal fast breeder reactor **(LMFBR)**

LIQUID METAL FAST BREEDER REACTOR

- LMFBR produces plutonium according to following scheme:



$_0n^1 + _{92}U^{238} \longrightarrow _{92}U^{239}$ (unstable)
(fast) ($T_{1/2}$= 23.5 minutes)
$_{93}Np^{239} + _{-1}\beta^{\circ}$
($T_{1/2}$ = 2.4 days)
$_{94}Pu^{239} + _{-1}\beta^{\circ}$
($T_{1/2}$ = 24400 years)

DIFFERENCES BETWEEN THERMAL REACTOR AND LMFBR

CONVENTIONAL REACTOR	LMFBR
Moderator	No moderator
Coolant is ordinary water or gas	Na is coolant
Run continuously	Requires maintenance after 15 days
Uses $_{92}U^{235}$ as fuel	Uses $_{92}U^{238}$ as fuel

NUCLEAR REACTIONS & NUCLEAR FUSION IN THE SUN

- Fusion reaction is production of heavy nucleus by nuclear reaction of light nuclei
- There are two types of reactions

(i) **D-D Reaction**

$$^2_1H + ^2_1H \longrightarrow ^4_2He + 24MeV$$

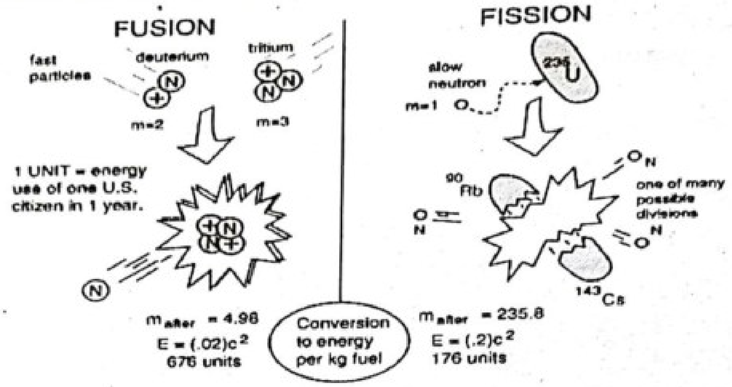
$$^2_1H + ^2_1H \longrightarrow ^3_1H + ^1_1H + 4.0MeV$$

$$^2_1H + ^2_1H \longrightarrow ^3_2He + ^1_0n + 3.3MeV$$

(ii) **D-T Reactions**

$$^2_1H + ^3_1H \longrightarrow ^4_2He + ^1_0n + 17.6MeV$$

- Fusion is more energetic than fission.



Nuclear Reaction in the Sun

The source of energy in the sun is nuclear fusion

- The temperature of its core is about 20 million degrees Celsius and its surface temperature is about 6000 degrees Celsius. Its energy is due to fusion reaction called p-p reaction.

Proton-Proton cycle

$$_1H^1 + {}_1H^1 \longrightarrow {}_1H^2 + {}_{+1}\beta^\circ + \upsilon$$

$$_1H^2 + {}_1H^1 \longrightarrow {}_2He^3 + \gamma$$

$$_2He^3 + {}_1He^1 \longrightarrow {}_2He^4 + {}_{+1}\beta^\circ + \upsilon$$

- Stars like sun maintain their shape and pressure due to radiation pressure.

COMPARISON OF ISOTOPES, ISOBARS & ISOTONES

	ISOTOPES	ISOBARS	ISOTONES
Atomic Number	Same	Different	May or may not be the same
Mass Number	Different	Same	May or may not be the same
No. of Neutrons	Different	May or may not be the same	Always same

RADIATION EXPOSURE

- Radiations can damage **living tissues**. The degree of damage and kind of damage depend on type, energy and dose of radiation. Incident radiations ionize the body cell, and then change biochemistry of the cell. A damaged cell **may die** or **begins to work in wrong way** e.g. sometimes radiation changes the chemistry of cells in such a way hat they begin to reproduce rapidly leading to a **condition called cancer.**
- Damage to ozone layer is done through following sources: -

(i) **Chemical** industry

(ii) **Nuclear** tests

(iii) **CFC (chlorofluorocarbons)**

(iv) **Aerosol** sprays and plastic foam industry

- Some radiation in the environment is added by human activates like diagnostic x-ray, nuclear facilities, hospitals, research and industrial establishments, colour television, luminous watches and tobacco leaves.

EFFECTS OF RADIATIONS

Effects of radiations are of two types:

(i) **Somatic effect:**

These are direct effects on body e.g. **skin burns, loss of hair**, ulceration, stiffening of lungs, drop in white blood cells and contraction in eyes etc. These effects can be cured if the dose is small.

(ii) Genetic effects:

These affect (alter) the chemistry of genes and cause mutation e.g. **cancer, different syndromes etc.**

These effects are incurable and pass on to future generation.

(iii) Biological Effects

ABSORBED DOSE

Absorbed dose D defined as the energy E absorbed from ionizing radiation per unit mass m of the absorbing body. $D = \frac{E}{m}$

Its SI unit is gray (Gy). $1Gy = 1Jkg^{-1}$

An old unit is rad, an acronym for radiation absorbed dose.

1 rad = 0.01Gy

Equal doses of different radiations do not produce same biological effect. The effect also depends on the part of the body absorbing the radiation.

- For the same absorbed dose, α -particles are 20 times more damaging than X-rays
- Neutrons are particularly more damaging to eyes than other parts of the body.

EQUIVALENT DOSE

It is defined as the product of absorbed dose and RBE (relative biological effectiveness)

1 Sv = 1 Gy x RBE (SI Unit)

Old Unit

1 rem = 0.01 Sv

UNIT OF RADIOACTIVITY

- Becquerel (Bq)
  1 Bq = one disintegration per second
- Curie (Ci)
  1 Ci = 3.7×10^{10} Bq

USES OF RADIATIONS

- C-14 is one of useful tracer that can help in the understanding of **photosynthesis.**
- I-131 and Na-24 are used to check **cracks in pipes.**
- Radiation therapy is a process of destruction of cancerous cells deep into body e.g. Co-60 & I-131 are **used to treat cancers.**
- Tumors are treated by **γ-rays.**
- Radio processes in space give information about **structure of stars.**
- When ethylene is radiated with γ-rays, it is polymerized into polyethylene, which is used to **produce soft and flexible products.**
- **Sterilization** is a process of killing of germs with β-particles or γ-rays.
- Radiation treatment can **preserve food** and other eatables.
- γ-gauges are used for preparing or measuring the thickness of high density and thicker materials such as **steel, Al & rubber**. In such gauges, Co-60 is used as γ-rays source.
- β-gauges are used for preparing or measuring the thickness of thin sheets of low density materials e.g. paper. In **such gauges, Sr - 90** is **used as a β-rays source**
- **Radiography** is employed to check cracks of cavities in metal casting, faults in welding & heavy machinery.
- Ratio of C-14 to C-12 found in dead matter is a measure of time span **since death.**
- β particle is used for **superficial skin therapy.**
- α particle is used for deep **skin therapy.**

- Activation analysis (γ-ray energy measurement) is applied to determine concentration of elements in a given sample and to estimate corrosion and wear of machinery.
- Technetium - 99 has given rise to positron emission tomography.
- The ratio of $_{62}Pb^{206}$ — $_{92}U^{238}$ is used to determine age of rocks.

INTERESTING CONSIDERATIONS

- The age of **pyramids** is 4500 years.
- By Ar-40, we can measure dates as back as one million years ago.
- Amino acids have been discovered on **meteorites.**
- To destroy a tumor, we place small pellets of radionuclide near it e.g. radon seed (radon in miniature gold capsule). After destruction of tumor, we remove them.
- Different radioisotopes accumulate in specific parts of body e.g.

Radioisotopes	Site of Accumulation
Iodine	*Thyroid gland*
Cobalt	*Liver*
Phosphorus & Calcium	*Bones*

RADIOGRAPHY

- γ-rays radiographs are used in **medical diagnosis**
- Cracks and cavities in castings or pipes are detected by γ ray scanning.
- The gamma camera is used to detect γ radiations from sites in the body where a γ - emitting isotope is located.

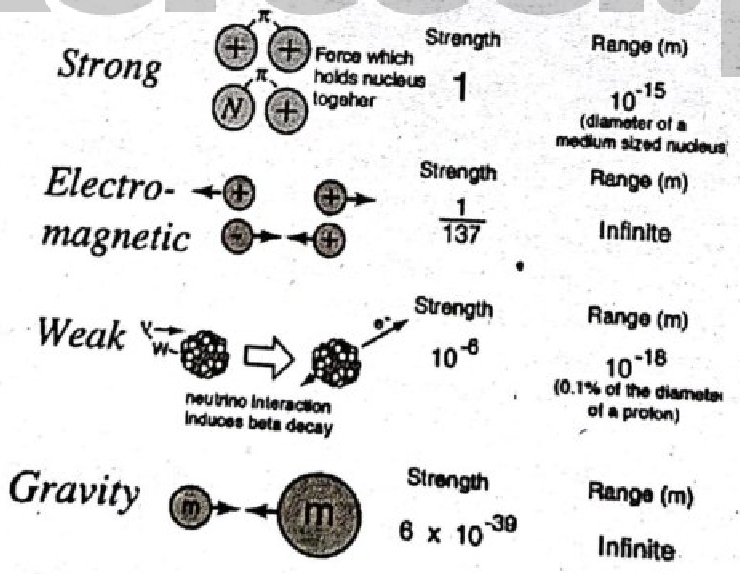
BASIC FORCES OF NATURE

There are now four basic forces in nature.

(i) Gravitational force (long range)
(ii) Electromagnetic force (long range)
(iii) Strong nuclear force **(short range, 10^{-15}m) attractive**
(iv) Weak nuclear force **(short range, 10^{-17}m) repulsive**

In 1979, the physics noble prize was conferred on Glashow, Weinberg and Abdul Salam for the unification of electromagnetic and weak forces.

FUNDAMENTAL FORCES



BUILDING BLOCKS OF MATTER

Subatomic particles are divided into three groups

(i) Photons

(ii) Leptons (electron, muons and neutrinos)

(iii) Hadrons

There are two types of hadrons

(a) Baryons (the particles equal in mass or greater than protons are called baryons e.g. protons and neutrons)

(b) Mesons (the particles lighter than proton e.g. π mesons)

A pair of quark and anti-quark makes a meson and 3 quarks make a baryon.

- *Elementary particles are the basic **building blocks**.*
- All photons and Leptons are elementary particles.
- Hadrons are not elementary particles.
- Hadrons are composed of elementary particles called *quarks*.
- *Matter belongs to either lepton group or quark groups.*

PRACTICE EXERCISE

30 mins Time Yourself

(1) Curie is the unit of

(a)half life
(b) intensity
(c) radioactivity
(d)none of these

(2) The radioactive element has the half life of 1600 years, after 6400 years what amount will remain undecay

(a)1/16
(b)1/8
(c)1/2
(d)1/4

(3) The binding energy per nucleon is maximum for

(a)$_{26}Fe^{56}$
(b)$_{92}U^{235}$
(c)$_{56}Ba^{141}$
(d)$_{2}He^{4}$

(4) In typical nuclear fission reaction the energy released is approx:

(a)8MeV
(b)931MeV
(c)200Mev
(d)931eV

(5) Which of the following undergo fission reaction easily by slow moving neutrons

(a)U-235 , Pu-239
(b)Pu-239 , Th-234
(c)U-238 , Rn-232
(d)Th-234 , U-238

(6) Neutron and proton are commonly known as ____________

(a)nucleon
(b)meson
(c)boson
(d)quartz

(7) Half life of radium is 1590 years. In how many years shall the earth loss all its radium due to radioactive decay?

(a)1590×10^{6} years
(b)1590×10^{12} years
(c)1590×10^{24} years
(d)never

(8) Which one of the following radiation possesses maximum penetrating power?

(a)α-rays
(b)β-rays
(c)γ-rays
(d)all have equal penetrating power

(9) Radioactivity is a ____________.

(I) Spontaneous activity
(II) Chemical property
(III) Self disintegration property

Which of above statements is/are correct?

(a) I & II
(b) II & III
(c) III & I
(d) I, II & III

(10) Quenching gas used in G.M counter is

(a)bromine
(b)helium
(c)neon
(d)all of these

(11) Transuranic elements have atomic number ____________

(a)greater than 72
(b)greater than 82
(c)greater than 92
(d)greater than 102

(12) Nuclear forces exist between ____________

(a)proton-proton
(b)proton-neutron
(c)neutron-neutron
(d)all of the above

(13) Mass defect per nucleon is ____________

(a) binding energy of nucleus
(b) packing fraction
(c) average energy of nucleus
(d) all of above

(14) Tick the correct statement

(a)moderators slow down the neutrons
(b)moderators bring the neutrons to rest
(c)moderators absorb the neutrons
(d)moderators reflect the neutrons

(15) The bombardment of nitrogen with α-particles will produce ____________
(a)neutron (b)proton
(c)electron (d)positron

(16) Diameter of an atom is approximately____________
(a)10^{-12}m (b)10^{-11}m
(c)10^{-10}m (d)10^{-14}m

(17) Which of the following isotopes is normally fissionable?
(a) $^{238}_{92}U$ (b) $^{239}_{93}Np$
(c) $^{235}_{92}U$ (d) $^{4}_{2}He$

(18) Fission chain reaction in a nuclear reactor can be controlled by introducing _________
(a)iron rods (b)graphite rods
(c)cadmium rods (d)platinum rods

(19) Which one of the following radiations possesses maximum velocity?
(a)α-rays (b)β-rays
(c)γ-rays (d)all of above have same speed

$\lambda = \frac{h}{mv}$
$v = \frac{h}{\lambda m}$
$v \propto \frac{1}{\lambda}$ $v \propto \frac{1}{m}$

(20) Charge on neutron is ______________
(a)+ 1.6 x 10^{-19} C (b)zero
(c)-1.6 x 10^{-19} C (d)no definite charge

(21) Mass of neutron is ___________
(a)1.67 x 10^{-31} kg (b)1.67 x 10^{-27} kg
(c)9.1 x 10^{-31} kg (d)1.67 x 10^{-19} kg

(22) Nuclei having the same mass number but different atomic number are__
(a)Isotopes (b)Isobars
(c)Isotones (d)Isomers

(23) A mass spectrograph (spectrometer) sorts out ____________
(a)molecules (b)atoms
(c)elements (d)isotopes

(24) Sum of the masses of constituent nucleons as compared to the mass of the resultant nucleus is ______________
(a)smaller (b)greater
(c)same (d)some times smaller some times greater

(25) An α-particle is emitted from $_{88}Ra^{226}$. What is the mass and atomic number of the daughter nucleus?

Mass number	atomic number
(a) 224	86
(b) 220	80
(c) 222	86
(d) 226	87

(26) The unit of radioactivity 'curie' is equal to ____________
(a)3.74x10^{9} disintegration per sec (b)3.70x10^{10} disintegration per sec
(c)3.55 x 10^{10} disintegration per sec (d)3.60 x 10^{10} disintegration per sec

(27) In liquid metal fast breeder reactor, the type of uranium used is ______
(a) $_{92}U^{235}$
(b) $_{92}U^{238}$
(c) $_{92}U^{234}$
(d) $_{92}U^{239}$

(28) Radioactive materials can be identified by measuring their ______
(a) hardness
(b) mass
(c) half life
(d) total life

(29) If one or more of the neutrons emitted during fission can be used to build up further fission then the reaction is self sustained and is known as ___
(a)fission reaction
(b)fusion reaction
(c)chain reaction
(d)chemical reaction

(30) During an encounter with an atom, α-particle knocks out______
(a)protons
(b)electrons
(c)neutrons
(d)nothing

(31) The path of β-particle is ______
(a)rectilinear
(b)curved
(c)zigzag or erratic
(d)elliptical

(32) Which of the following radiations are suitable for the treatment of an infection in the interior of the body?
(a)α-rays
(b)β-rays
(c)γ-rays
(d)X-rays

(33) Various types of cancer are treated by ______
(a)cobalt-60 Correct
(b)strontium-90
(c)carbon-14 ×
(d)nickel-63

(34) Charge on α-particles is ______
(a)+1
(b)+2
(c)–2
(d)-1

(35) β-particle ionizes an atom ______
(a)through direct collision
(b)through electrostatic attraction
(c)through electrostatic repulsion
(d)all of above

(36) T.V sets and microwave ovens emits ______
(a)X-rays
(b)α-rays
(c)β-rays
(d)γ-rays

(37) Strontium-90 is used as ______
(a)β-particle source
(b)α-particle source
(c)γ-rays source
(d)neutron source

(38) The penetration power of β-particle as compared to α-particle is ______
(a)10 times more
(b)100 times more
(c)100 times less
(d)10 times less

(39) Geiger counter is suitable for ______
(a)fast counting
(b)extremely fast counting
(c)slow counting
(d)all situations

(40) A α-particle can produce fluorescence in ______
(a)ZnS
(b)barium platinocyanide
(c)sodium iodide
(d)all of above

(41) CFC is used in ______
(a)refrigeration
(b)aerosol spray
(c)plastic foam industry
(d)all of above

(42) **Average distance covered by α-particle in air before its ionizing power ceases, is called its __________**

(a)trajectory
(b)range
(c)firing level
(d)limit

(43) **Which one of the following possesses greater penetration power?**

(a)α-rays
(b)β-rays
(c)γ-rays
(d)neutron-rays

(44) **The most useful tracer is**

Imp

(a)Sr-90
(b)I-131
(c)Ca-41
(d)C-14

(45) **γ-rays are electromagnetic waves like**

(a)light waves
(b)heat waves
(c)micro waves
(d)x-rays

(46) **Charge on β-particle is**

(a)±1
(b)–1
(c)+2
(d)–2

(47) **β-particles possess greater penetration power than that of α particles due to its_________**

(a)smaller ionization power
(b)greater ionization power
(c)neither greater nor smaller ionization power
(d)same ionization power

(48) **Enriched uranium is better as a fuel for a nuclear reactor because it has greater proportion of**

(a) ^{233}U
(b) ^{235}U
(c) ^{238}U
(d) ^{239}U

(49) **The maximum safe limit dose for persons working in nuclear power station are _________**

(a)1 rem per week
(b)5 rem per week
(c)4 rem per week
(d)3 rem per week

(50) **Radiations are used for the treatment of skin of a patient is**

(a)α-rays
(b)β-rays
(c)γ-rays
(d)X-rays

SAMPLE PAPER BY KIPS

45 mins Time Yourself

(1) A rock is dropped off a cliff and strikes the ground with an impact velocity of 30 m/s. How high was the cliff?

(a) 10 m (b) 20 m

(c) 145 m (d) 45 m

(2) Which of the following is a dimensionless quantity?

(a) $\frac{\text{momentum}}{\text{acceleration}}$ (c) $\frac{\text{volume}}{\text{area}}$

(b) $\frac{\text{energy per unit volume}}{\text{pressure}}$ (d) $\frac{\text{force}}{\text{power}}$

(3) If earth shrinks to half the present radius the duration of day and night will be

(a) 24 hours (b) 12 hours

(c) 6 hours (d) 3 hours

(4) Light roofs are blown of during wind storm. It is because of

(a) less weight of roof (b) more height of roof

(c) difference in pressure (d) all are correct

(5) The maximum velocity of SHM is a_0 the period of oscillation is

(a) $2\pi x_0/a_0$ (b) $2\pi a_0/x_0$

(c) $2\pi a_0 x_0$ (d) $2\pi/a_0 x_0$

(6) In wave motion the least distance between two points which are out of phase is

(a) λ (b) $\lambda/2$

(c) $3\lambda/2$ (d) $\lambda/4$

(7) A particle performing SHM when its displacement is 3 cm, its acceleration is 12cm s^{-2}. It is vibrating with period

(a) 4π Sec (b) 2π Sec

(c) π Sec (d) 4π Sec

$a = x_0 \omega^2$ $\frac{12}{3} = \omega^2 \Rightarrow \omega^2 = 4$ $\frac{2\pi}{T} = 2$ $\boxed{T = \pi s}$

(8) In case of spectrometer circular scale, graduated in half degree, is attached with

(a) collimator (b) telescope

(c) turn table (d) cross wire of telescope

(9) A satellite moving round the earth constituents

(a) inertial frame (b) non inertial frame

(c) neither inertial nor non inertial frame (d) both inertial and non inertial frame

(10) Satellite is launched from earth into orbit. What happened to the mass of satellite and weight of satellite.

	Mass	**Weight**
A)	Increases	Increases
B)	Remain same	Decreases
C)	Decreases	Increases
D)	Increases	decreases

(11) A spherical body is moving through fluid (say water). If the temperature of fluid increases the terminal velocity of the fluid

(a) decreases (b) increases

(c) does not change (d) increases or decreases depend upon the.

(12) The width of the depletion region of a junction is reduced under forward bias because

(a) more charge carriers are available

(b) number of minority charge carriers are reduced

(c) majority carriers on both sides of junction are driven towards it

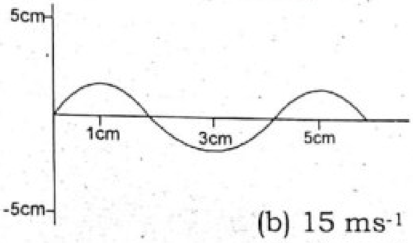
(d) doping level is increased

(13) **In a Young's double slit experiment if the monochromatic source is replaced by a source of white light,**
(a) Fringes will be alternately white and black
(b) Central fringe is white and other are coloured
(c) Central fringe is dark and others are coloured
(d) Central fringe is coloured and all other are white

(14) **In a two input logic gate both inputs are at 0 and the output is 1 the gate would be**
(a) NAND
(b) NOR
(c) XNOR
(d) any of given gates in a, b and c

(15) **Einstein was awarded Nobel Prize for his work on**
(a) theory of relativity
(b) nuclear fission
(c) photoelectric effect
(d) all are correct

(16) **Figure shows the shape of part of a long string in which transverse waves are produced by attaching one end of the string to tuning fork of frequency 250Hz. What is the velocity of the waves?**



(a) 25 ms^{-1}
(b) 15 ms^{-1}
(c) 20 ms^{-1}
(d) 10 ms^{-1}

(17) **Four molecules have speeds of 2 kms^{-1}, 3 kms^{-1}, 4 kms^{-1} and 5 kms^{-1}. The rms speed of these molecules in kms^{-1} is**
(a) $\frac{\sqrt{54}}{4}$
(b) 3.5
(c) $\frac{\sqrt{54}}{2}$
(d) $3\sqrt{3}$

(18) **The atomic number and mass number of a nucleus is Z and A. there new value after emission of two alpha and two beta radiation is**
(a) Z-2,A-4
(b) Z-2,A-8
(c) Z-4,A-4
(d) Z-4,A-8

(19) **The particle which are lighter than protons are called**
(a) photons
(b) mesons
(c) hadrons
(d) baryons

(20) **What is the particle emitted during the reaction**
${}_4^9Be + {}_2^4He \rightarrow {}_6^{12}C + ?$
(a) proton
(b) neutron
(c) deuterium
(d) beta-particle

(21) **A wire of length 50 cm and cross-sectional area 1 mm^2 is made of a material of Young's modulus 2×10^{10} N/m^2. How much work is done in stretching the wire through 1mm?**
(a) 8×10^{-1}J2
(b) 2×10^{-4}J
(c) 4×10^{-2}J
(d) $\times 10^{-2}$J

(22) **The mathematical notion for NAND operation is**
(a) X = A + B
(b) X = A.B
(c) $X = \overline{A+B}$
(d) $X = \overline{A.B}$

(23) **If R is the range of projectile then its K.E be maximum after covering a horizontal distance**

(a) $\frac{R}{4}$ (b) $\frac{R}{2}$

(c) 3R/4 (d) R

(24) **An alpha particle moves through potential difference 1 volt it may gain K.E equal to**

(a) 1 eV (b) 2 eV

(c) 3 eV (d) 4 eV

(25) **When charges become twice and their separation also become twice then coulomb's force between them**

(a) remains same (b) become half

(c) become double (d) become eight time

(26) **With rise in temperature the resistance of semiconductor.**

(a) increases (b) decreases

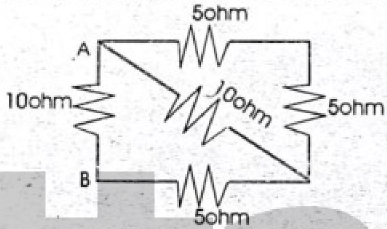
(c) remains same (d) becomes infinite

(27) **When two resistances are connected in series they have**

(a) same resistance value (b) same voltage across them

(c) only one current path (d) different resistance value

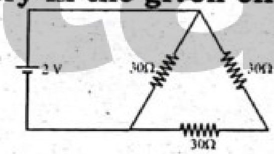
(28) **What is the equivalent resistance between A and B in the figure given below**



(a) $R_{eq} = 5\Omega$ (c) $R_{eq} = 15\Omega$

(b) $R_{eq} = 10\Omega$ (d) $R_{eq} = 20\Omega$

(29) **The current through the battery in the given circuit is**



(a) $\frac{1}{45}$ A (b) $\frac{1}{15}$ A

(c) $\frac{1}{10}$ A (d) $\frac{1}{5}$ A

(30) **The path difference between two identical sinusoidal waves is $\lambda/6$ their phase difference is**

(a) 30^0 (b) 60^0

(c) 180^0 (d) 15^0

CHAPTER-12

1	b	11	b	21	c	31	d
2	c	12	b	22	c	32	c
3	a	13	d	23	d	33	d
4	b	14	a	24	b	34	b
5	a	15	d	25	b	35	b
6	c	16	d	26	c	36	c
7	b	17	a	27	b	37	c
8	d	18	d	28	b	38	a
9	b	19	a	29	a	39	a
10	b	20	a	30	c	40	b

CHAPTER-13

1	a	11	a	21	b	31	c
2	d	12	c	22	c	32	b
3	a	13	a	23	b	33	a
4	a	14	d	24	a	34	c
5	b	15	c	25	c	35	d
6	b	16	c	26	a	36	c
7	b	17	c	27	d	37	b
8	d	18	a	28	c	38	c
9	a	19	b	29	a	39	d
10	a	20	a	30	d	40	a

CHAPTER-14

1	c	11	b	21	c	31	d
2	c	12	d	22	c	32	a
3	c	13	d	23	b	33	d
4	b	14	a	24	a	34	d
5	b	15	b	25	d	35	c
6	a	16	d	26	a	36	b
7	a	17	d	27	a	37	a
8	d	18	c	28	c	38	d
9	c	19	b	29	d	39	a
10	d	20	c	30	a	40	d

CHAPTER-15

1	d	11	b	21	d	31	a
2	c	12	d	22	d	32	b
3	c	13	c	23	a	33	d
4	b	14	b	24	a	34	b
5	d	15	a	25	c	35	c
6	d	16	a	26	b	36	a
7	a	17	c	27	a	37	b
8	d	18	d	28	c	38	b
9	c	19	b	29	a	39	c
10	d	20	b	30	d	40	a

CHAPTER-16

1	b	11	d	21	b	31	a
2	c	12	b	22	a	32	b
3	b	13	d	23	c	33	d
4	c	14	a	24	b	34	d
5	d	15	b	25	d	35	b
6	a	16	d	26	a	36	a
7	c	17	a	27	b	37	b
8	c	18	b	28	c	38	b
9	b	19	b	29	b	39	c
10	c	20	d	30	d	40	d

CHAPTER-17

1	d	11	c	21	d	31	c
2	a	12	b	22	c	32	b
3	c	13	b	23	b	33	c
4	d	14	a	24	c	34	c
5	b	15	b	25	a	35	c
6	b	16	c	26	b	36	d
7	b	17	d	27	d	37	b
8	d	18	b	28	a	38	b
9	a	19	b	29	d	39	c
10	c	20	c	30	c	40	a

CHAPTER-18

1	a	11	c	21	c	31	a
2	a	12	c	22	a	32	d
3	d	13	a	23	b	33	b
4	c	14	d	24	b	34	b
5	d	15	c	25	d	35	b
6	b	16	a	26	b	36	d
7	c	17	c	27	b	37	a
8	c	18	b	28	b	38	b
9	a	19	a	29	b	39	b
10	a	20	B	30	a	40	a

CHAPTER-19

1	d	11	c	21	c	31	b
2	d	12	b	22	d	32	a
3	d	13	c	23	d	33	c
4	b	14	c	24	c	34	b
5	b	15	b	25	a	35	b
6	d	16	b	26	d	36	d
7	a	17	d	27	b	37	b
8	c	18	c	28	a	38	c
9	b	19	c	29	c	39	a
10	a	20	c	30	d	40	b

CHAPTER-20

1	b	11	c	21	b	31	b
2	a	12	c	22	c	32	a
3	d	13	b	23	c	33	c
4	c	14	c	24	b	34	d
5	b	15	c	25	a	35	b
6	c	16	a	26	d	36	c
7	a	17	a	27	c	37	c
8	a	18	d	28	a	38	a
9	c	19	c	29	b	39	a
10	d	20	a	30	d	40	c

CHAPTER-21

1	c	11	c	21	b	31	c	41	d
2	a	12	d	22	b	32	c	42	b
3	a	13	b	23	d	33	a	43	d
4	c	14	a	24	b	34	b	44	d
5	a	15	b	25	c	35	c	45	d
6	a	16	c	26	b	36	a	46	a
7	d	17	c	27	b	37	a	47	a
8	c	18	c	28	c	38	b	48	b
9	c	19	c	29	c	39	c	49	d
10	a	20	b	30	b	40	d	50	a

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1	d	11	a	21	d
2	b	12	c	22	d
3	c	13	b	23	d
4	c	14	d	24	b
5	d	15	c	25	a
6	b	16	d	26	b
7	c	17	c	27	c
8	c	18	b	28	a
9	b	19	b	29	c
10	b	20	b	30	b